DESIGN OF A HYPERMEDIA-BASED EDUCATING SYSTEM FOR THE CONSTRUCTION OF KNOWLEDGE

THESIS

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THESIS

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Preface

In all my years of education, it always seemed like I had one of two choices; I could try to learn the curriculum materials, or I could try to get good grades. It was a rare class where achieving one objective meant achieving the other. Generally, these were two separate goals, requiring different sorts of study. Achieving them both required a tremendous amount of effort.

I was always confused about that. How was it that I could get good grades without learning? How could I learn, and not get good grades? After studying the works of David Ausubel, W. Edwards Deming and Stafford Beer, the answers are obvious. Current educational programs, ill designed for the variety they confront, promote short-term learning. This thesis provides the required background for developing an educating system which promotes long-term concept mastery by adjusting to student variety.

To Professor Dan Reynolds, thank you for your help in making this thesis a reality. I can safely say I've learned more working with you on this thesis than I have in the 63 other credit hours I've taken in this degree program. It's truly been one of the most meaningful learning experiences I've ever had. It's unfortunate that the biggest things you've learned from me are the behavioral patterns and inclinations of an INTP.

Special thanks to a special woman, my lovely wife Veronica. The wonderful part of you that you've shown me in the last few months has helped me to remember just how lucky I am to be sharing a life-time with you.

Crispoldo A. Campelli

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Abstract

This thesis proposes the design for an educating system which is robust to student variety. The design is founded on educational psychology, with quality principles playing a major role in establishing the design criteria. Since educating is a management-intensive activity, management cybernetics also play a key role in the design.

The need for an effective educating system stems from ever-increasing requirements for learning. The Total Quality Management (TQM) program, a Department of Defense (DoD) initiative geared towards providing quality weapon systems, promises to be a learning-intensive endeavor. The Japanese have shown quality requires extensive training and continuous education. For a quality culture to take hold, all DoD members must be educated about quality. In addition, computer technology can play a major role in transforming the DoD. Before the computer can be used effectively, however, workers and managers must be made aware of the possible benefits.

The need for an effective educating system stems, in part, from the need to educate workers about quality techniques and computer technology. At the same time, both quality and computers offer to revolutionize educating systems. A computer-based learning system, founded on a quality design, will not only meet student needs, but will

also contain features to assure continuous systemic improvement.

The proposed design solution centers around a hypermedia-based, computer-supported collaborative system. While research stems from the need for effective means of educating the workforce about quality, the design solution is not limited to any particular subject. Recommendations for system development follow the design solution. These recommendations lay out a plan for integrating individual courses into a cohesive program of study.

DESIGN OF A HYPERMEDIA-BASED EDUCATING SYSTEM FOR THE CONSTRUCTION OF KNOWLEDGE

I. Introduction

> I realized that the people I had been interviewing were on the edge of a historical transformation, as important as that which had been experienced by the eighteenth- and nineteenth-century workers about whom I had read so much and imagined even more.... The world of industrialism, its means and its methods, was about to succumb to the same silence that had already engulfed the tools of the craftsman's shop. What kind of world would emerge from this silence and how would we feel in it? Would it be possible, at this early stage in the historical process to learn enough to frame the choices that would be laid open? Might a clearer grasp of these choices enable us to avoid the worst mistakes of the past? (Zuboff, 1988:viii)

Creating the Future

A Vision. Consider this vision for the future of the Air Force. Leaders, concerned about product quality, take on the commitment to improve the system. As a result, workers begin tracking contractual actions, and identifying possible bottlenecks. System-induced delays are discovered, identified, and eliminated. Programs that clearly exceed expected results, as well as those that fail, are studied with an eye on improving the Air Force as a whole. Based on systems analysis, senior leaders enact changes resulting in increased efficiency. Schedule times drop and improved quality products enter the field within budget. A new philosophy fills the Air Force, and suggestions flow in from all levels which further decrease systemic variability, ultimately increasing product quality and cutting total costs.

An Alternate Vision. Consider another future. Air Force leaders track contractual actions; however in this future, top performers are rewarded. The vast majority, constrained by a system demanding more performance than it allows, are unable to achieve what the system asks of them. This majority is encouraged to try harder, do things right, and improve the quality of their work. Morale drops, productivity decreases, schedules slip, and low quality dominates. After a downward spiral, the Air Force achieves a low-quality, low-performance equilibrium, with ever-increasing costs and schedules.

The Age of the Smart Machine

Fresh Choices. Regardless of which choices the Air Force makes, computer technology and automation will usher in a new era. In her book In The Age of the Smart Machine, Shoshana Zuboff states

> A powerful new technology, such as that represented by the computer, fundamentally reorganizes the infrastructure of our material world. It eliminates former alternatives. It creates new possibilities. It necessitates fresh choices. (Zuboff, 1988:5)

What is it about the computer that necessitates fresh choices? In the past, workers used their minds and bodies to accomplish tasks. Workers kept mental records of individual activities, limiting access to this information. In addition, workers maintained records of output characteristics, but these records, like those dealing with the activities themselves, were typically buried within the minds of the workers themselves or recorded on paper that no one ever saw.

Computerized automation offers to change all of this. Computer programs now drive many applications once limited to both skilled and unskilled laborers. Like Hansel and Graetel dropping bread crumbs in the forest, computer programs leave a verifiable software trail detailing actions taken. Unlike the breadcrumbs, which were eaten by the birds, this trail remains intact when actions are completed.

While extending worker output by translating coded software into action, automation also generates records from the output of those activities which it automates. This self-generating output is new to computer-driven processes (Zuboff, 1989:29-30). In addition, records are now being loaded into massive data-bases accessible to virtually everyone in the organization (Zuboff, 1988:126-127).

<u>Informating</u>. The translation of previously hidden knowledge into computerized records is what Shoshana Zuboff refers to as "informating." As a result of informating, records previously maintained by individual workers are now available to everyone in an organization via the computer. This provides an organization with the opportunity "to more fully develop the economic and human potential" (Zuboff, 1988:7).

Information technology opens new communications channels, giving virtually everyone in the organization access to critical data. Senior management, by striking a few computer keys, now has access to records input by the lowest level workers. This offers a link between senior management and working level personnel that has not previously existed. In addition, workers can now share information among themselves. The challenge facing managers today is learning what can be done to exploit these new lines of communication.

The choices management makes today will dominate future possibilities.

> Imagine this scenario: The new technology becomes the source of surveillance techniques that are used to ensnare organizational members or to subtly bully them into conformity.... Imagine the alternative: The new technological milieu becomes a resource from which are fashioned innovative methods of information sharing and social exchange. (Zuboff, 1988:7)

In the second scenario, workers are given access to information from throughout the organization and unleash their collective wealth of knowledge in a synergetic fury. To create a future which exploits this knowledge bank, managers must first see the possibilities inherent in the future and enact changes.

Informating, and the limitless potential it offers, is merely one of many amplifying capabilities inherent in today's computers. The computer, with its vast storage and rapid retrieval capabilities, is an able tool, ready to enhance the capabilities of those using it. This feature, which enables workers to increase their abilities, is what Doug Engelbart refers to as augmentation.

> The components of an augmentation system are the bundle of all things that can be added to what a human is genetically endowed with, the purpose of which is to augment these basic capabilities in order to maximize the capabilities that a human or human organization can apply to the problems and goals of human society. (Engelbart and Hooper, 1988:17)

The promise of augmentation technologies lies in the newly discovered ability to share information via access to the computer. Exploiting these new capabilities requires a comprehensive re-education program. Workers and managers at all levels must learn to make sense of the data present and available through the computer. Everyone must be retrained to exploit the computer as an augmenting device. This retraining "requires a *learning environment* if it is to be nurtured as a core organizational process" (Zuboff, 1988:307-308).

<u>Pathologies of American Management</u>

Initiating the education process will be no simple task. Providing for increased sharing of information requires overcoming a great deal of management resistance. Governance within the workplace generally stifles attempts by workers to learn about overall processes. As a consequence, workers generally understand little of the overall production processes to which they contribute. This results primarily from deliberate management action to sequester knowledge of the overall process (Zuboff,1988:239).

> The strategies chosen by employers and managers to achieve efficient coordination of the industrial apparatus appropriated the knowledge of craft work in order to make it the basis for rationalized bureaucratic control. (Zuboff, 1988:239)

Instead of capturing and exploiting the knowledge workers possess, bringing it to bear on the production process to increase productivity, management has focused research on routinizing and fragmenting worker tasks. While individual workers hold the keys to their individual tasks, management has resisted relinquishing the reigns to the overall production process. Instead, management has kept workforce knowledge segmented among the various functional areas and individual labor tasks. This serves to maintain the need for management functions to integrate the various fragments of work effort.

While routinizing the work of laborers, managment removed the more routine functions from management activity. This led to the creation of an intermediate body of workers to handle the more trivial tasks (Zuboff, 1988:107). As a result, management has become fairly well insulated from organizational operations. Senior management, for the most part, is incapable of understanding problems associated with organizational processes. This ignorance of organizational processes has led to the inability of America to compete in many world markets (Deming, 1988:2).

A New Philosophy

If organizations wish to succeed, management must create an environment conducive to continuous improvement. This requires radical changes.

> Transformation of American style of management is not a job of reconstruction, nor is it revision. It requires a whole new structure, from foundation upward. Mutation might be the word. (Deming, 1988:ix)

Unlike mutation, however, the transformation must be orderly, based on sound principles. Using well structured re-education programs, the Japanese have methodically restructured processes, creating quality systems, and increasing productivity and output. As a result, Japan now dominates many world markets.

Many experts agree that re-education with an emphasis on quality is necessary for any organization seeking to remain viable. This re-education must address the four components, shown in Figure 1, which are critical to effective leadership for change: purpose, trust, vision and cooperation.

```
              PURPOSE
             /   :   \
            /    :    \
           /     :     \
          /    TRUST    \
         /    /     \    \
        /    /       \    \
     VISION   -----   COOPERATION
```

Figure 1-1. Elements of Leadership for Change

Management must initiate the transformation by establishing constancy of purpose.

> Long-term commitment to new learning and new philosophy is required of any management that seeks transformation. The timid and the fainthearted, and people that expect quick results, are doomed to disappointment. (Deming, 1988:x)

The transformation also requires vision. Part of this vision involves looking into the future and seeing the changes necessary to bring about improved quality. In addition, an enterprise must also envision future corporate capabilities. To meet customer needs, management must couple a vision of future capabilities with visions of future customer needs (Deming, 1988:167).

Managers must be able to envision improvements in quality and show commitment to eliminate low quality work. However, to make improved quality a reality, managers must also remove barriers which prevent various functional areas from cooperating (Deming, 1988:62-63).

Cooperation and the resulting synergy provide the vehicle for meeting customer needs. Trust is vital to creating and maintaining a cooperative atmosphere. American management, however, has constructed elaborate sytems of rules and regulations to assure workers do their jobs properly. Such systems, based on lack of trust, constrain workers and hamper efforts to improve quality. In order to effectively improve quality, management must take on leadership to create a trusting and cooperative environment that fosters continuous improvement. (Deming. 1988:59-60)

A system based on cooperation, with everyone trying his or her best, is not good enough; managers and workers must know what to do.

> Best efforts are essential. Unfortunately, best efforts, people charging this way and that way without guidance of principles, can do a lot of damage. Think of the chaos that would come if everyone did his best, not knowing what to do. (Deming, 1988:19)

Japan has realized that best efforts only pay off when the workforce is properly educated. Learning has become a pivotal element in the Japanese strategy of implementing quality.

> The Japanese plant manager faces much the same pressures to reduce cost that his American counterpart does. He has flexibility to cut costs in many areas, but one area he cannot reduce is his training budget. (Scherkenbach, 1988:95)

Investment in learning is a cost effective means of increasing the value of human resourses.

> The educative process generates "human capital," it adds value, it creates value. In the marketplace of ideas very little cost is incurred in comparison to the benefits accrued. (Gowin, 1987:46)

To fully exploit human capital, everyone from top management on down must be educated about the requirements for continous improvement (Deming, 1988:86). With its requirements for learning, the workplace may be viewed as the "real classroom."

The workplace requires modes of learning generally neglected in the typical classroom. Instead of passively assimilating knowledge created by others, workers require self-motivated, self-managed discovery (Zuboff, 1988:306-307).

The self-managed discovery learning demanded in the workplace is inherently disorderly, and requires freedom from conventional linear textual presentations of material (Engelbart and Rheingold, 1988:10). Hypertext, a network of interlinked modules of information, provides the necessary freedom. Hypertext uses the unique properties of the computer to link modules of information, referred to as nodes, non-linearly--in a way that is not possible when using two-dimensional paper. The modular nature inherent in a document consisting of nodes gives the author a great degree of flexibility (Conklin, 1987:56).

Hypertext supports self-managed discovery learning. The modularity inherent in a hypertext document enables the author to create a document by handling concepts individually, then integrating and ordering them. Establishing and re-establishing the hierarchy of the document is handled by either creating or dissolving links between nodes. Additionally, nodes may be added to a hypertext document without altering the flow of the original text (Conklin, 1987:54).

Justification for Research

Total Quality Management. The Air Force and the rest of the military services are confronted with decreasing budgets and allegations of over-priced systems that do not function properly. Partly in response to these allegations, the Department of Defense (DoD) has embarked on the Total Quality Management (TQM) program, an ambitious effort to instill quality into all areas of the DoD. The major thrust of the TQM program involves efforts to provide higher quality products at lower prices.

Informating, a powerful tool for increasing learning and innovation, can play a big role in any efforts to improve quality and productivity. The Air Force and the rest of the world are now confronted with orchestrating viable informating strategies. By giving workers access to organizational information, management can foster a teamwork mind-set which will ultimately unleash a burst of synergy. However, this environment is not a function of the technology applied, but is more a function of management philosophy (Deming, 1988:12).

Properly orchestrated informating strategies can result in new solutions to organizational problems and achieving organizational goals. The key to implementing viable informating strategies lies in educating everyone in an organization about the benefits. However, everyone must be educated first about creating quality processes. While computer technology offers heretofore unheard of capabilities, computers are generally underutilized, or even worse, misused.

> People are intimidated by the computer. They can not tell it what data or charts they need: instead, they

> take whatever the computer turns out, which is reams of figures.
>
> An advertisement of a computer sets forth this accomplishment--instant figures at the press of a button on sales as of yesterday, or of accounts receivable.
>
> This is of course a great accomplishment, electronically. But for the purposes of management, it may be only another bear trap. A single figure (as of yesterday, for example) by itself conveys little information. It is a candidate for misuse. (Deming, 1988:139)

The Role of Education. The only way to prevent such misuse is to educate everyone about the possibilities. Once everyone understands the characteristics of a quality system, informating strategies can be developed and shared among the workers. This, in turn, can result in unheard of increases in capabilities (Zuboff, 1989:29).

Effective learning cannot take place if the forces governing interaction in the social environment are too restrictive (Gowin, 1987:57-58). Many organizations not only fail to provide adequate training for their workers, but actually restrict attempts by workers to implement and exploit informating strategies (Zuboff, 1988:250-251). Before workers can be educated, managers must first come to understand the contributions informating strategies can make to organizational success.

Educating provides the key to unlocking the potential of informating strategies. All educating events must consider four commonplaces: curriculum, teaching, learning, and governance. The curriculum is made up of instructional materials. Teaching and learning occur as the instructor and the student share the meanings of these instructional materials. This process occurs "as if teacher and student were standing side by side looking together at the curriculum" (Gowin, 1987:62). Governance consists of all the factors exerting social control during the sharing process (Gowin, 1987:25).

The only way to insure effective learning is to design a quality learning system. A need exists for an instructional process that fosters active and personal construction of new knowledge during any educational event. The linking and reshuffling of concepts which occurs during the learning process could be facilitated by a presentational method which facilitates the rapid rearrangement of non-linear text.

Research Focus

What are the qualities and characteristics of a process that fosters self-managed meaningful reception and discovery learning?

Purpose of Research

Research will center on developing a process which fosters a meaningful learning environment. Predictor variables will be identified for use in monitoring and controlling the learning environment, and ultimately, for maximizing meaningful learning. Research will attempt to answer the following questions:

1. What are the key elements of a process that facilitates construction of new knowledge?

2. What variables are useful in determining the stability of the learning environment?

3. How can these variables be manipulated to maximize meaningful learning?

4. How can current technology be applied to create a process that fosters knowledge construction?

Limitations of Research

Research is limited to determining the effectiveness of a process based on the application of hypertext and hypermedia to the creation of a meaningful learning environment. Research does not address the effects of drill and practice, linear-based computer-aided instruction, nor will it involve non-computer related facilitation.

Research Overview

This thesis contains five chapters consisting of this introduction, a review of literature, research methodology, results, and the conclusion.

The literature review presents the concept set required for understanding the research methodology. Chapter II also includes a detailed analysis of the educational psychology upon which the design work for any learning process must be founded.

> It is educational psychology that should be at the heart of instructional theory, and not vice versa. Before we can design a learning environment to optimize learning of some specific element of knowledge, we must know how students learn in general. (Ausubel, 1978:356)

The concepts presented in the literature review conflict with much of the superstitious knowledge generally put forward in educational psychology arenas. The material dealing with quality also conflicts with prevailing superstition. Since a firm understanding of both educational psychology and quality is necessary to fully comprehend the methodology and interpret the results, failure to read the literature review may render much of the methodology confusing. In addition to learning and quality, the literature review addresses hypermedia.

The methodology (Chapter III) is presented in three parts. It begins by addressing the design requirements for an educational system by first addressing the student level. Next, the design requirements are expanded to include the classroom. The final section looks into requirements levied at the program level to integrate a program of study.

Chapter IV contains the actual design results. This chapter mirrors the Chapter III approach. Chapter IV establishes the design requirements for a system beginning at the student level, expanding to the classroom level, and finally addressing the program of study as a whole.

Chapter V summarizes the main points of Chapters I through IV. In addition, Chapter V addresses unanswered questions and proposes new areas for research. This chapter finishes with final recommendations and a vision for the future.

II. Review of Literature

The thrust of TQM is to get better products out to the field. This drive for improvement comes in the face of Graham-Rudman-Hollings, and the associated decreasing budgets. The only way to achieve product improvement with less money is through improved know-how.

According to R. Buckminster Fuller, know-how is the true measure of wealth (Fuller, 1979:447). Quality, when defined as continuous improvement of product and service, serves to increase know-how, while educating spreads know-how. Methods and processes which amplify the intellectual abilities of man can be used to accelerate the acquisition and spread of know-how. The relationship between know-how, quality, educating, and augmentation of intellect is shown in Figure 2-1.

```
              AUGMENTATION
              OF INTELLECT
               /    :    \
              /     :     \
             /      :      \
            /   KNOW-HOW    \
           /     /     \     \
          /     /       \     \
       EDUCATING -----  QUALITY
```

Figure 2-1. Interaction Between Know-How, Educating, Quality, and Augmentation of Intellect

Know-How

Know-how increases as man increases the ratio of all non-redundant operative advantage to all non-redundant input of material, energy, and time used to generate the given operative advantage (Fuller, 1979:447). Military circles have a phrase which captures Fuller's notions of true wealth: getting more bang for the buck.

One might describe TQM as the DoD program instituted to get more bang for the buck. By applying quality methods, the DoD can increase the know-how used for managing weapon system acquisitions. In order to derive the full benefits of improvements to the acquisition system, everyone must be educated about quality. Quality is the responsibility of everybody (Deming, 1988:86-90).

All areas can benefit from continuous improvement, and education is no exception. Improved educational methods can provide a better educated workforce in less time, so workers can spend less time learning about TQM and more time doing their jobs.

Computers are gaining increased use in education. Impressive storage and retrieval capabilities, along with such features as interactive audio and video make the computer an attractive classroom device. However, the computer cannot simply be added to the educational system. Just as air power redefined warfare, the computer will redefine education. Using quality principles, the educational system must be redesigned to accommodate the augmenting capabilities of the computer.

Redesigning the educational system involves addressing academic management. The educational system, when considered for a degree program, consists of three management levels. The first level involves the student as a knowledge construction worker, managing the learning for his or her various classes. The next management level is the classroom, where instructors and students share meanings. The third management level is the program under which the efforts from various classes are integrated to produce a degree. In addition, other management levels also exist above the program level within a given institution.

Designing a computer supported educational system involves integrating the computer into all levels of an educational system. Effective integration can only occur when system designers have a firm grasp of what education really is.

Educating

Any effort to design an augmentating process for education requires a thorough understanding of the factors which dominate information sharing. Sharing lies at the heart of education, and occurs when the instructor shares the meanings of the curriculum with the student. Teaching, learning, curriculum, and the forces governing sharing constitute the four commonplaces of educating (Gowin, 1987:11).

> Using educative materials of the curriculum, teacher and student aim at congruence of meaning. It is as if teacher and student were standing side by side looking at the curriculum. (Gowin, 1987:62)

The four commonplaces, shown in Figure 2-2, have equal weight within the educating system. (Gowin, 1987:11)

```
             CURRICULUM
            /     :     \
           /      :      \
          /       :       \
         /   GOVERNANCE    \
        /     /       \     \
       /     /         \     \
   LEARNING -------- TEACHING
```

Figure 2-2. The Four Commonplaces of Educating

The curriculum is a collection of claims of knowledge or value which are selected because of their criteria of excellence. The curriculum materials are shared in a socially controlled setting (Gowin, 1987:25).

D. Bob Gowin refers to the forces which control sharing in the social setting as governance. "Governance is power in a social setting which is required to bring together teaching, curriculum, and learning" (Gowin, 1987:153), and controls meanings and effort in educating. Governance controls the curriculum by establishing the content of the instructional materials. Governance also controls the efforts involved in both teaching and learning by establishing systems of rewards and penalties, as well as dictating the freedom allowed to both students and instructors (Gowin, 1987:154).

<u>Teaching</u>.

> It is incontrovertible that pupils respond affectively to the personality characteristics of a teacher ... They not only admire teaching skill ... and good classroom control, but are also highly appreciative of fairness ... and sympathetic understanding. ... Nevertheless, from the standpoint of his or her principal role in our culture, it is self-evidently more important that a teacher be instructionally effective. (Ausubel, 1978:504)

Teaching, "the achievement of shared meaning in the context of educating" (Gowin, 1987:62), demands instructional effectiveness. The instructor, as the presenter of the instructional materials, plays a pivotal role in the educational process. The effectiveness of the instructor is determined by his or her knowledge of the subject matter, pedagogical competence, communicative skills, and ability to maintain high levels of motivation within the classroom (Ausubel, 1978:498-499). The interactions between these critical instructor qualities are shown in Figure 2-3.

```
               PEDAGOGICAL
               COMPETENCE
              /     :     \
             /      :      \
            / ABILITY TO    \
           /    MOTIVATE     \
          /     /     \       \
         /     /       \       \
KNOWLEDGE -----  COMMUNICATION
```

Figure 2-3. Critical Instructor Qualities

For effective teaching to occur, the instructor must have an adequate grasp of the subject matter--a cogent and cohesive understanding. This is necessary in order to explain the meanings of the instructional materials. In addition, the instructor must effectively select and organize the learning materials to facilitate the meaningful acquisition of concepts by the students (Ausubel, 1978:498-499). This involves determining the amount and difficulty of material presented, the steps the learner must take in order to grasp the material, the underlying logic behind the presentation, and the sequence and pacing of the presentation. This area also includes the use of instructional aids, such as films (Ausubel, 1978:351-352).

When arranging instructional materials, the instructor must recognize "the most important thing influencing learning is what the learner already knows." (Ausubel, 1978:351-352). The instructor should introduce major concepts prior to subordinate concepts. This helps to assure that adequate anchoring concepts are present for subsuming new concepts. Emphasis must be placed on all concepts which are used to anchor new concepts (Ausubel, 1978:352).

Selecting and arranging the instructional materials in a manner that meets student needs is not enough. The instructor must also possess the communicative skills necessary for presenting the materials in a form appropriate for the level of understanding of the learner (Ausubel, 1978:498).

No matter how effectively the instructor selects, organizes, presents and explains the instructional materials, the students do the actual learning. By removing barriers to effective learning and instilling in students the desire to learn, instructors may unleash natural desires to learn so that students bring all their abilities to bear on educational activities. Instructors motivate students, in part, by displaying warmth and understanding. In addition, imagination, as well as enthusiasm and excitement for subject matter is contageous, and is often reflected in the attitudes of the students (Ausubel, 1978:498, 505-506).

Curriculum. The curriculum materials form "a logically connected set of conceptually and pedagogically analyzed knowledge and value claims" (Gowin, 1987:109). This analysis centers around an educating event. The four critical elements involved in the construction of curriculum materials are shown in Figure 2-4. Analyzing these elements reveals several important concepts.

Claims. There are two types of claims which make up the curriculum materials: knowledge claims and value claims.

> A knowledge claim is a product of inquiry. An inquiry includes a question, concepts, methods and techniques as constituents of the process that produces the knowledge claim. The knowledge claim is the answer to the question. (Gowin, 1987:101)

```
              CLAIMS
           /     :     \
          /      :      \
         /   EDUCATING   \
        /      EVENT      \
       /      /     \      \
      /      /       \      \
   CONCEPTUAL ------- PEDAGOGICAL
    ANALYSIS            ANALYSIS
```

Figure 2-4. Key Components Involved in the Construction of Curriculum Materials

A knowledge claim can be viewed simply as a research finding. A value claim, on the other hand, "asserts the worth of something" (Gowin, 1987:105). The value claim assigns value to a knowledge claim. This value may be asserted across a broad spectrum, ranging from statements about usefulness and clarity all the way to moral implications and assertions of truthfulness (Gowin, 1987: 105-106).

Events and Objects. Knowledge and value claims are generated by observing some event or object and conducting a conceptual analysis. An event is "anything that happens or can be made to happen," while an object is "anything that exists and can be observed" (Novak and Gowin, 1988:4). Knowledge and value claims are the results of analysis of primary sources of knowledge. The curriculum must include materials which are logically connected. Since the claims are products of inquiry, the claims which make up the curriculum may be regenerated from primary sources of knowledge by analyzing appropriate educative events (Gowin, 1987:109).

It is critical that the curriculum materials presented in the classroom be located and interpreted from primary sources themselves; they must be understood and interpreted in a manner that facilitates concept acquisition by the student (Gowin, 1987:89,109). This analysis is critical for two reasons. First, if the instructor does not fully understand a concept set, he or she has no way of telling if the student has grasped the meanings in the curriculum. In addition, by blazing a trail from the educating event to knowledge and value claims, the instructor provides a path for the students to follow to confirm or question the knowledge or value inherent in the claims.

<u>Conceptual Analysis</u>. A conceptual analysis involves analyzing the educative event to create the knowledge and value claims of the curriculum materials. This analysis begins with the focus question. A focus question directs research attention on an aspect or aspects of an observed event or object (Novak and Gowin, 1988:60).

The above conceptual analysis is the same analysis which the student should use in the creation of knowledge. Once attention is focused on an educative event, relevant principles, theories, and concepts are brought to bear on the event. Records of the event which have been collected are subsequently transformed and interpreted. Based on this analysis, claims of knowledge and value are made (Novak and

Gowin, 1988:5-6; Gowin, 1987:101-107,109). A useful tool for executing the conceptual analysis is the V-heuristic, shown in Figure 2-5.

```
                        \  Focus Question  /
  Philosophy             \                /          Value Claims
                          \              /
     Principles            \            /       Knowledge Claims
                            \          /
           Theories          \        /          Transforms
                              \      /
              Concepts         \    /        Records
                                \  /
                                 \/
                               Event
                               Object
```

Figure 2-5. Gowin's Vee (Adapted from Gowin, 1987:107)

Pedagogical Analysis. Along with conceptual analysis, the instructor applies pedagogical analysis to the curriculum materials. This provides the feedback required for continuously improving curricula. Previous curricula are assessed as to their strengths and weaknesses, and curricula are updated to include improvements (Gowin, 1987:109).

Learning. "Acquiring understanding, which is what one gets as a result of accumulating explanations, is the highest goal of learning" (Scriven, 1976:217). Learning is "the active reorganization of an existing pattern of meaning" (Gowin, 1987:124) by the learner. Through this reoganization, the learner creates meaning. As students learn, they acquire new meanings through the personal construction of knowledge (Novak and Gowin, 1988:4). In the classroom, the student can be viewed as worker who produces learning.

The nature of meaningful learning suggests that current levels of understanding form the foundation for future understanding. What the learner knows constantly increases based on reconciling newly acquired concepts with the existing cognitive structure. In this way, learners create what they know; they personally construct meaning for new concepts, then create the relationships between these new concepts and other concepts which they have already mastered (Von Glaserfeld, 1987:8).

This constructivist perspective has serious management implications. The personal construction of knowledge required for effective learning places the student at the center of learning activities. Within the classroom, the student is the manager and coordinator of his or her personal construction of knowledge. While serving in this capacity, each student must integrate the interaction of learning process (rote-meaningful) and instructional strategy (reception-discovery) with his or her own cognitive abilities and learning preferences to maximize personal construction of knowledge. In short, the student is responsible for managing the learning process and altering learning activities to meet personal needs. These needs are dictated by various attributes of the students themselves.

When managing learning, students must begin with their own abilities and characteristics. These abilities and characteristics dictate what actions are taken towards integrating learning processes and instructional strategies for the effective creation of knowledge.

Learning Process. The process through which learning takes place involves various levels of rote and meaningful learning.

Rote Learning. Rote learning is an assembly of unrelated or non-meaningfully related concepts.

> In rote learning ... new knowledge may be acquired simply by verbatim memorization and arbitrarily incorporated into a person's knowledge structure without interacting with what is already there. (Novak and Gowin, 1988:7)

Rote learning is characterized by the sort of memorization used when initially learning word spellings or the multiplication tables. Even advanced memorization techniques, though they relate concepts to each other in quite imaginative ways, are void of meaningful relationships between new concepts and the existing cognitive structure. Initially, rote-learned concepts contribute little to the understanding the learner has of the world around him, and may even confuse him. Rote learning can be effective, however, when the learner does not have the cognitive structure to support the meaningful learning of a new concept (Ausubel, 1978:60). In addition, some things, such as phone numbers, are best remembered with high levels of precision (Novak, 1986:26).

Meaningful learning occurs more rapidly and leads to improved retention over rotely learned materials (Ausubel, 1978:147-149). Rote learning, however, does have its place in learning environments.

> Rote learning is always necessary when an individual acquires new information in a knowledge area completely unrelated to what he already knows. Also, some types of information are inherently meaningless; telephone numbers, nonsense syllables ... (Novak, 1986:77)

<u>Meaningful Learning</u>. With meaningful learning, on the other hand, the learner constructs substantive and non-arbitrary relationships between new concepts and the existing cognitive structure. Substantive association is non-verbatim and occurs when the learner defines a concept using other concepts present within the cognitive structure, i.e. puts a concept in his or her own words. Thus, the learner redefines a concept in terms already present in his or her existing cognitive structure (Ausubel, 1978:630). Non-arbitrary association involves hierarchy, progressive differentiation, and ultimately, integrative reconciliation (Ausubel, 1978:628).

<u>Hierarchy</u>. For learning to be meaningful, concepts must be introduced at the proper hierarchic level within the existing cognitive structure. This means the learner must recognize that the new concept is subordinate to more inclusive, higher-order concepts already present within his or her cognitive structure. In addition, the new concept must also be understood to subsume less inclusive,

lower-order concepts (Novak and Gowin, 1988:97; Ausubel, 1978:66-67, 125-129).

Progressive Differentiation. Concept relationships and hierarchies are enhanced through the process of progressive differentiation. Progressive differentiation occurs when the learner links concepts to a new concept and adds relationships between a new concept and other concepts (Ausubel, 1978:124). These concepts and relationships serve to clarify concepts and differentiate them from other similar concepts.

Progressive differentiation is an ongoing process that fortifies the position of concepts within the cognitive structure. This means that concepts are never fully learned. Instead, concepts are constantly being learned, further clarified, and made more subsumptive, based on ever-increasing levels of differentiation (Novak and Gowin, 1988:99).

Cognitive Dissonance and Integrative Reconciliation. At some point in time, conflicting or seemingly conflicting concepts will find their way into the cognitive structure of the learner. This conflict between concepts, referred to as cognitive dissonance, is resolved via integrative reconciliation (Ausubel, 1978:124-125).

Integrative reconciliation occurs when the learner discovers new relationships between either related sets of concepts or related sets of relationships between concepts (Novak and Gowin, 1988:103). These discovered relationships generally result from attempts by the learner to reconcile conflicting concept sets. Through integrative reconciliation, the learner creates new meanings for existing concepts. These newly created meanings enable the learner to better understand the concepts and relationships between concepts which already exist within his or her cognitive structure (Ausubel, 1978:124-125).

Integrative reconciliation can shake the very foundation of the existing cognitive structure. This happens when new concepts and relationships are introduced which lead to apparent inconsistencies. These inconsistencies force the learner to radically reorganize existing patterns of meaning within his or her cognitive structure.

This occurs, for example, when a young child is introduced to the notion that the earth is round. Initially, a child with no concept of gravity cannot understand how people can stand on the "under-side" of the world without falling off. This is because the child is only aware of concepts which tell him that objects fall from higher elevations to lower elevations. If people are standing "upside-down" on the "under-side" of the world, the child knows no good reason why those people should not fall off.

Once the child comes to a fuller understanding of gravitational forces, and understands that up and down are relative to center of mass, the child is able to reconcile the apparent inconsistency, and realizes there is no "underside" of the world.

Conventional presentational media serve to impair integrative reconciliation.

> The principle of integrative reconciliation of cognitive structure when achieved through programming instructional material can be best described as antithetical to the usual practice among textbook writers of compartmentalizing and segregating particular ideas or topics within their respective chapters or subchapters. Implicit in this latter practice is the assumption (perhaps logically valid, but certainly psychologically untenable) that pedagogic considerations are adequately served if overlapping topics are handled in a self-contained fashion, so that each topic is presented in only one of the several possible places where treatment is relevant and warranted. It also assumes that all necessary cross-referencing of related ideas can be satisfactorily performed, and customarily is, by students. (Ausubel, 1978:192)

This clearly points out the pedagogical benefit of a presentational medium which supports ease of cross-referencing between related concepts and which allows treatment of material wherever that treatment is relevant.

Meaningful learning offers three advantages over rote learning: longer retention, increased capacity to acquire other concepts, and meaningfully learned concepts leave "finger-prints" on the cognitive structure, even after they are forgotten (Novak, 1986:85).

The psycological processes driving rote and meaningful learning differ. However, learning tasks can involve aspects of both rote and meaningful acquisition of concepts (Ausubel, 1978:24). Acquiring meanings rotely may involve simply memorizing concepts in a serial manner without regard to the relationships between concepts. Each new concept is linked to the previous concept without regard to hierarchy. This yields a serially-linked series of randomly associated concepts which have been acquired verbatim.

If concepts are presented hierarchically, the student may memorize the hierarchic associations between concepts. This simply means the material is meaninglessly learned with its proper hierarchy. The learner has not yet defined the concept in terms of currently understood concepts. While the appropriate relationships may have been drawn between the proper concepts, these relationships mean nothing to the learner. Rotely learned material, whether it be serially or hierarchically structured, is fragmented from the existing cognitive structure.

Learning style may also include aspects of both rote learning and meaningful learning. The student may still acquire a new concept rotely, not associating this concept with the existing cognitive structure. However, the student may then define new concepts in terms of this rotely acquired concept, associating newly acquired concepts with this newly seeded structure. Thus, this newly learned concept set is not acquired using the exact words originally presented to the learner. In addition, these concepts are acquired hierarchically, and placed at the appropriate subsumptive level.

What the rote/meaningful learner does which the "pure rote" learner does not do is he or she substantively and nonarbitrarily associates new concepts with each other. However, the rote/meaningful learner does not create substantive and nonarbitrary associations between these new concepts and the vast majority of the existing cognitive structure, but instead limits concept linking to the newly acquired seed structure. What the rote/meaningful learner creates is an island of concepts which are meaningful in relation to each other but which lack substance within the context of the total cognitive structure. This student does not have a single orderly cognitive structure, but instead possesses fragmented islands of meaning.

"Pure" meaningful learning occurs when all concepts are acquired meaningfully. Unlike rote/meaningful learning, meaningful learning involves linking all newly acquired concepts with the existing cognitive structure. Therefore, as concepts are acquired, they are meaningfully associated with what the learner already knows. This yields an increased number of relationships between a greater number of concepts, which in turn strengthens the total cognitive structure. The level of understanding associated with new concepts is increased since relationships are drawn between what has been newly learned and what is already known.

The greater the degree of meaningful learning, the more ability the student will have to manipulate the newly learned concepts. This is because meaningful learning, by its very nature, involves associating new concepts with concepts the learner already understands. Furthermore, meaningful learning processes lead to better organized cognitive structures. Increasing levels of rote learning, on the other hand, cause newly acquired concepts to remain discrete and isolated from the rest of the cognitive structure (Ausubel, 1978:146).

Instructional Strategy. Both rote and meaningful learning can take place under one of two instructional strategies. These two strategies are reception learning and discovery learning (Ausubel, 1978:25).

Reception Learning. Reception learning involves the learner acquiring new concepts and the relationships between them in their final form.

> *In reception learning* (rote or *meaningful*), the entire content of what is to be learned is presented to the learner in final form. The learning task does not involve any independent discovery on the student's part. (Ausubel, 1978:24)

Reception learning can occur rotely such as memorizing word spellings. However, reception learning can also be meaningful, such as when an instructor clarifies complex relationships between concepts. In the latter case, the learner is able to draw relationships between concepts based on information that is presented to him.

Discovery Learning. Unlike reception learning, discovery learning is a self-motivated mechanism, and requires greater levels of creativity and imagination on the part of the learner. With discovery learning,

> the learner must rearrange information, integrate it with [the] existing cognitive structure, and reorganize or transform the integrated combination in such a way as to generate a desired end product or discover a missing means end relationship. (Ausubel, 1978:24-25)

The product of this rearrangement and reorganization process is a set of concepts or relationships between concepts, which can then be rotely or meaningfully added to the existing cognitive structure. Discovery learning can occur meaningfully, as in scientific research involving a rigorous application of inductive and deductive processes. It can also occur rotely, such as in trial and error puzzle solving. The key aspect of discovery learning is that it is a self-managed acquisition of the material learned (Ausubel, 1978: 24-26).

Reception and discovery learning each have their place in the classroom. Reception learning is the preferred pedagogical approach when large quantities of abstractions and concepts must be learned. This is the case for the majority of material which must be learned (Ausubel, 1978:117).

Discovery learning, on the other hand, has great value in concept formation (Ausubel, 1978:527-528). This is especially useful when cognitive development is insufficient to support meaningful assimilation of material (Ausubel, 1978:537). In addition, discovery learning in laboratory situations is a principal means of creating new knowledge (Ausubel, 1978:26).

As with rote and meaningful learning, the psychological processes driving reception and discovery learning differ significantly, and learning can involve various levels of reception and discovery (Ausubel, 1978:24). Pure reception learning involves the assimilation of concepts and the relationships between concepts when these concepts and relationships are presented in their final form. This occurs in many text book applications and conventional classroom lectures.

However, not all learning involving text books is of a receptive nature. A student may search several texts in search of concepts that will assist him in formulating subsumptive concepts. In this case, the student is using both reception and discovery learning. The text books are providing concepts which are received in final form. However, the researcher is drawing the relationships between the concepts and actually formulating the subsuming concepts himself.

Research involves greater degrees of discovery learning. In "routine" research, the learner generally uses reception learning to acquire the cognitive background needed to support further learning. This background is then applied as he or she functions in a discovery learning mode.

Scientific research of an exploratory nature involves the highest level of discovery learning. In this instance, the researcher is generally observing reality and formulating concepts based on the behavior of the phenomena he or she is observing. Thus, he or she discovers new concepts based on these observations.

Like meaningful and rote learning, reception and discovery learning are at opposite ends of a continuum, and learning can contain aspects of both reception and discovery learning (Novak and Gowin, 1988:8). The relationship between learning process and instructional strategy is shown in Figure 2-6.

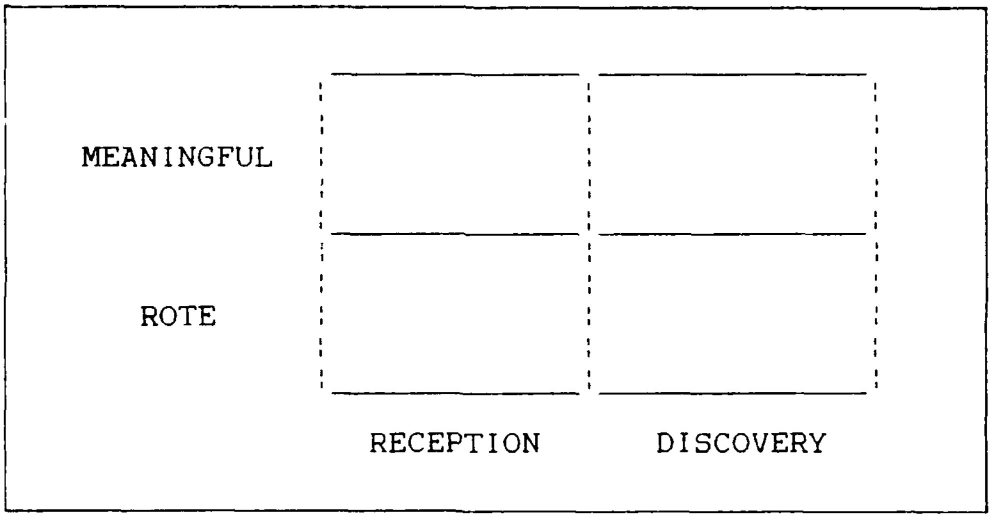

Figure 2-6. Relationship Between Learning Process and Instructional Strategy
(Adapted from Ausubel, 1978:25)

<u>The Student</u>.

<u>Cognitive Structure</u>. According to Ausubel,

> If we had to reduce all of educational psychology to just one principle we would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly. (Ausubel, 1978:v)

"What the learner already knows" is in essence his or her cognitive structure, "the total content and organization of an individual's ideas" (Ausubel, 1978:625). David Ausubel further views the cognitive structure as a "hierarchically organized and established body of knowledge that is organically relatable" to learning activities (Ausubel, 1978:166).

The cognitive structure may be viewed as a relational database system in which the learner has established links and cross-links between various concepts. This database has a hierarchic structure in which more inclusive concepts hold higher positions within the structure (Novak, 1986:25). The utility of such a structure in learning is a function of both content and organization. Content involves the various concepts which make up the cognitive structure, while organization refers to the relationships between the concepts. (Ausubel, 1978:163)

The cognitive structure can be influenced in one of two ways. First, it can be influenced substantively, that is to say, by the nature of the concepts and principles presented. It can also be influenced programmatically, by the methods used to present, arrange and test the new material (Ausubel, 1978:164).

The cognitive structure is influenced by the other variables of learning, since meaningful learning is defined as the substantive and non-arbitrary association of concepts to the existing cognitive structure. However, the cognitive structure is both a dependent and an independent variable in learning. This means that any amount of learning impacts the ability of the learner to further learn (Ausubel, 1978:167).

> Let us examine, for example, those short-term learning situations where just a single unit of material is learned and transfer to new learning units is not measured. Here the effects of even a single practice trial both reflect the existing cognitive structure and induce modification of that structure, thereby influencing subsequent practice trials. (Ausubel, 1978:165-166)

This complicates any assessment of learning, since the predictor variable most critical to learning is constantly changing based on life experience.

Since the cognitive structure is constantly changing during any meaningful learning event, the most important variable of learning is, by definition, unstable during meaningful learning. Furthermore, the conflict or apparent conflict associated with the period of cognitive dissonance that precedes integrative reconciliation can lead to weaknesses in the cognitive structure. This may occur if the student chooses to reject one of the existing patterns of meaning, or rotely acquire them, in lieu of reconciling them. Neither of these options contributes to the increased ability to manipulate concepts (Ausubel, 1978:427).

Since the cognitive structure is so critical to what the student is able to learn, organizing and strengthening the relationships between concepts is important for improving meaningful learning and increasing the useful retention of newly learned material (Ausubel, 1978:167).

Three variables can be manipulated to enhance the effects of the existing cognitive structure. The first variable involves the amount of concepts in the existing cognitive structure which are suitably developed for anchoring new concepts. These anchoring concepts must be general and inclusive in nature and of an appropriate level of abstraction to be built upon. The second variable is discriminability. How easily are the new concepts discriminated from similar concepts which are already present in the cognitive structure? The final variable is the stability and clarity of the anchoring variables (Ausubel, 1978:168-169, 170, 182, 184).

Developmental Readiness. Developmental readiness involves various levels of development of the cognitive capacity to meaningfully acquire new concepts. This differs from the cognitive structure; developmental readiness involves the level of development and ability of learners to manipulate abstractions in order to add to the cognitive structure. Cognitive development deals with cognitive function, while cognitive structure involves concepts and the way they are organized.

An increase in cognitive development is characterized by a shift from concrete to abstract functioning. This shift is facilitated somewhat through the maturation process, but primarily by exposure to learning experiences.

Movement along the concrete abstract dimension can be characterized in three phases. The first phase, referred to as the preoperational phase, deals with the ability of learners to assimilate and manipulate primary abstractions. The second, the concrete-operational phase, involves the learner expanding his or her area of understanding to secondary abstractions. In this second phase, the learner uses concrete empirical props to synthesize and manipulate secondary abstractions. The final phase of development, the abstract logical phase, involves the learner manipulating both primary and secondary abstractions without referencing concrete empirical props (Ausubel, 1978:205-206).

<u>Preoperational Phase</u>. In the preoperational phase, the learner is limited to understanding primary abstractions and relationships between them. Learning occurs when the learner draws relationships between several concrete empirical reality examples and a concept. Once understood, primary abstracts can be used independent of reality for problem solving. The key aspect of the preoperational stage is that concrete experience must precede the acquisition of concepts and the drawing of relationships between concepts and the cognitive structure. Also, several examples are required prior to the acquisition of a concept (Ausubel, 1978:232-233).

<u>Concrete-Operational Phase</u>. The preoperational phase is followed by the concrete-operational phase in which the learner expands to secondary abstractions. Secondary abstractions are concepts which are not learned based on actual concrete empirical reality, but

are instead acquired via direct links with the cognitive structure. The concrete-operational phase is characterized by the learner using concrete empirical props. These props characterize the attributes of the concept and are "examples of abstracted properties of a concept." Only one example is needed to serve as a prop. The prop is simply a crutch used to relate an attribute to other concepts which are already understood. In the concrete-operational stage, the learner can manipulate both primary and secondary abstractions (Ausubel, 1978:233-236).

Abstract Logical Stage. In the abstract logical stage, the learner is free from the need for concrete empirical props. In this stage, the learner is able to acquire and manipulate secondary abstractions and the relationships between them without falling back onto any examples of concrete reality. This is truly a breakthrough, since the learner is now free to access all possible relationships between concepts and is no longer confined to drawing parallels with concrete reality. However, the educational system in the United States inhibits achieving this stage of development. Studies involving colleges in the United States indicate that roughly one in five students function at this level (Ausubel, 1978:236-238).

Once a learner has achieved the abstract logical dimension, it does not necessarily mean that he or she will function here for all areas of study. Any area of study involves movement from concrete to abstract functioning

(Ausubel, 1978:240). For this reason, all instructional material and curricula must consider learner development in the context of the concrete abstract dimension (Novak, 1986:140). This is critical for two reasons. First, the instructor must be careful not to overburden the learner. Second, the instructor must take advantage of the level of development which the learner has achieved (Ausubel, 1978:242-245).

Personality Factors. Personality factors involve differences in levels and types of motivation, adjustment and anxiety. These factors can be measured using the Myers-Briggs Type Indicator (MBTI). The MBTI is designed to assess character type and temperment based on assessing individual preferencs in the following categories: introvert versus extrovert; intuition versus sensing; thinking versus feeling; and desire for openess versus desire for closure. Personality factors may shift as students experiment with various preferences (Lawrence, 1987:1-6).

Roughly 70 percent of all students learn more effectively when learning interactively. This 70 percent is more comfortable doing something than contemplating what it would be like and prefers interacting with other students (Lawrence, 1987:40).

Another critical factor in learning involves learner preferences for handling conceptual material. The majority of students learn most effectively when presented with concrete examples followed by theory. Typical pedagogical practice, however, generally introduces the theory and then follows theory with examples (Lawrence, 1987:41).

Roughly 50 percent of the students seek approval and harmony, and try to be helpful to others; these students need feedback--they need to know how they are doing. The other 50 percent have a need to master material (Lawrence, 1987:50-54).

Finally, some students prefer well structured learning tasks, with well identified checkpoints for assessing their own progress. At the other end of the spectrum lie students who prefer a laissez-faire, unstructured environment, where they are free to control their own learning destiny (Lawrence, 1987:54-55).

Intelligence. Intelligence is a construct used to measure such qualities as reasoning ability, problem solving skills and verbal ability. However, the measurement of IQ does not represent the total realm of intelligence. Instead, IQ should be viewed as a fallable, functional measure of attributes used in problem solving. It should be stressed that IQ is strictly a measure of the abilities involved in scholastic learning (Ausubel, 1978:254).

Traditional notions of intelligence see it as being influenced by several factors. Absolute limits are imposed genetically. However, internal factors, such as motivation and external factors, such as the environment, determine how much of this innate ability is actualized, as well as the emphasis placed on the various components of intellect (Ausubel, 1978:274).

Intellectual ability plays a significant role in determining how much the learner can take in and meaningfully comprehend. However, intellectual ability, as measured by IQ tests, is not a good predictor for the level of meaningful learning when it is assessed by itself. Intelligence can certainly facilitate the ability of the student to acquire and apply constructive skills. However, other factors such as student study habits, self-control, aspirations, and persistence can have a greater impact on both what is learned and how it is learned (Ausubel, 1978:287-289).

Intelligence, as defined by the triarchic notions of Sternberg, can be changed as students act to alter mental self-management processes (Sternberg, 1988:76).

Motivation.

> After sixty years or more of research on motivation, perhaps the most striking conclusion that emerges from consideration of the staggering mass of research data and theory in this area is how little we really know about it. (Ausubel, 1978:399)

Educators recognize motivation as a catalyst for learning which drives students to get the most of their abilities. Motivation influences "focusing of attention, persistence, and increased frustration tolerance." In the absence of sufficient levels of motivation, many of the abilities of the learner may be unused (Ausubel, 1978:397-398). In spite of this,

> the weight of the evidence indicates that although motivation is a highly significant factor in and greatly facilitates learning, it is by no means an indispensible condition. (Ausubel, 1978:399-400)

However, subject mastery requires highly motivated meaningful learning (Ausubel, 1978: 399). Motivation improves the attention, effort, and readiness of the student, and thus has a significant impact on how well the student uses other abilities, such as intelligence. Motivation for learning can be characterized by four components (shown in Figure 2-7): cognitive drive, affiliative drive, ego enhancement, and aversive motivation (punishment) (Ausubel, 1978:398).

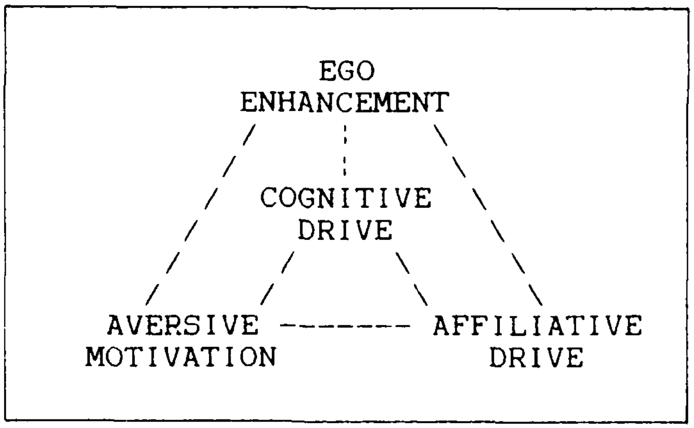

Figure 2-7. The Four Sources of Motivation

<u>Cognitive Drive</u>. Cognitive drive is a desire to learn and involves learning, knowing, and understanding as rewards unto themselves. "A major source of sustained intrinsic motivation for learning is the positive emotional experience that derives from meaningful learning." (Novak and Gowin, 1988:103). While this positive

emotional experience is not innate, it does have its roots in "the desire to know and understand" (Ausubel, 1978:402). Cognitive drive is acquired based on learning experience. The cognitive drive is intrinsic to the learning task, and operates totally independent of external approval (Ausubel, 1978:398; Novak, 1986:99). The cognitive drive is critical to classroom education, since much of what is learned has no application in day-to-day life, but serves as the basis for future learning (Ausubel, 1978:402).

Affiliative Drive. Unlike the cognitive drive, the affiliative drive is based on the learner attempting to gain the approval of others. The affiliative drive is prominent during early childhood, and is generally manifested in affiliation with parents and instructors. With increasing age, parents and instructors are displaced as students seek affiliation with their peers (Ausubel, 1978:412-413).

Ego Enhancement. Both the cognitive drive and the affiliative drive are generally replaced by ego enhancement with increased age. Ego enhancement involves the competence associated with achievements (Ausubel, 1978:398; Novak, 1986:99). Ego enhancement generally stems from any prestige associated with achievements or the possibility that knowledge of subject matter may contribute to future achievements (Ausubel, 1978:411).

Aversive Motivation. Punishment plays a dominant role in all structured and graded coursework. The prevailing opinion among educators is that while cognitive and affiliative drive and ego enhancement may serve as motivators for students, something more is needed to overcome typical human tendencies. (Ausubel, 1978:415).

> Teachers who imagine that the majority of their students would continue at their studies in the absence of structured programs, assigned work, deadlines, and examinations are living in a world of fantasy. (Ausubel, 1978:415)

However, W. Edwards Deming has a different experience with motivation and punishment. When asked about grading, Dr. Deming replied,

> "People ask how I grade my students. I give them all 'A.'... I give my students no time limit. ... It is all right with me. Just give me an outline of some kind. I give the 'A.' And what do I get? Great papers." (Walton, 1986:91)

Deming advocates removing all barriers to pride in workmanship; he feels that grades serve to impair the abilities of students to produce quality work and actually supress pride in academic workmanship (Walton, 1986:91). Perhaps by freeing students from the confines of a grading system, natural tendencies toward curiosity, exploration, and need for stimulation are allowed to dominate. Research is currently placing greater levels of emphasis in these areas (Ausubel, 1978:400-401).

Governance. Governance, the force which brings teaching, learning, and the curriculum together, dominates the interaction of the other three commonplaces. Governance influences the prevalent climate at an academic institution; climate can range from authoritarian to laissez-faire. This climate, in turn, establishes the degree of cooperation, interaction, and conformity involved in various classroom activities (Ausubel, 1978:465-466). The areas influenced by governance are shown in Figure 2-8.

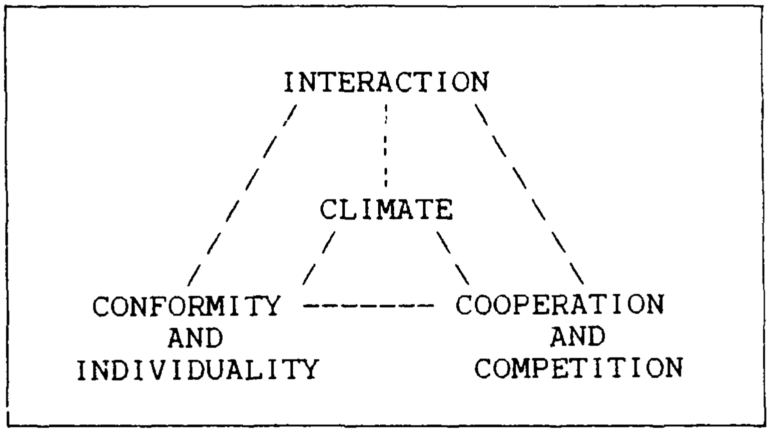

Figure 2-8. Areas Influenced by Governance

Educators view competition as a means of "narrowing the gap between capacity and performance" of the student. To this end, competition may serve a useful purpose. Competition must be controlled, however, since it can lead to hostility and anxiety if "winning" displaces learning as the ultimate goal. Too much of an emphasis on competition can lead to diminished interaction among students, and ultimately conformity (Ausubel, 1978:471).

Interaction involves the level of collaborative work. For interaction to be effective, instructors must select tasks from which students may derive some benefit by working with others. If a task can be more effectively accomplished alone, working in groups will prove ineffective (Ausubel, 1978:467).

Conformity is usually associated with adolescents. However, adults present adolescents with the model for conformity (Ausubel, 1978:481). Conformity can occur as students rebel against the prevailing climate (Ausubel, 1978:478), or can serve simply to unify the values of a given group (Ausubel, 1978:476).

The purpose of governance is to bring the teacher and the learner together to share the curriculum materials. When establishing governance, the administration must remember that "learning is the chief business of schools" (Gowin, 1987:122). The focus must be placed on effective learning. Learning, in turn, centers around choice.

> Choosing to learn a grasped meaning is a responsibility of the learner that cannot be shared. ... As we intelligently pursue our responsibilities for learning, we grow in power of choice, in power of action, and in flexibility of thinking. (Gowin, 1987:63)

Governance which acknowledges student responsibilities in the learning process must empower students with the ability to make choices which effect meaningful learning. Though choice is the responsibility of the learner, it cannot occur without freedom. However, restrictive governance can effectively prevent students from choosing the path of meaningful learning by restricting the very choices, actions, and thoughts necessary for effective learning (Novak, 1986:85).

When establishing governance, the learning system must balance the constraint required to bring teacher and learner together with the freedom learners require to choose the most effective means of constructing knowledge.

The sole purpose of governance in the classroom is to bring students and teachers together to share meanings held in the curriculum materials. Any force imposed on an educating environment should serve to improve collaboration between instructors and students, without interfering with student efforts to construct knowledge.

Management

Students construct knowledge in the enterprise known as the classroom. Any enterprise consists of individual operational units which produce outputs. In addition, an enterprise requires a stabilizing system which assists in integrating the various production efforts of day-to-day operations. Day-to-day efforts, in turn, must be balanced with environmental and future concerns.

Producing Units. Looking at the classroom this way, students may be viewed as the producing units in an educating system. In addition, students engaged in a given program of study budget their time among several classes, constructing knowledge for each class. In this case, one may view the student himself as an enterprise who operates and coordinates the knowledge creation activities for several classes.

The constructivist assimilative notions put forth by Ausubel clearly demonstrate student responsibilities for the creation of knowledge. Accepting the role of knowledge creator, the student must learn actively, staying critical of all concepts and relationships between concepts presented in the learning environment. In addition, the student must take an active part in trying to comprehend and retain newly acquired concepts. This means taking the necessary effort to translate newly presented concepts into terms that make sense to him. While these responsibilities are critical to learning, they generally receive little or no attention in conventional classrooms (Gowin, 1987:41-41).

Students attend to those responsibilities which they choose not to ignore by applying rote and meaningful learning processes, and using reception and discovery learning strategies. The student determines the frequency of study sessions. In addition, students vary the frequency of study to fit the complexity of the material. Finally, students establish the study methods used. These methods may include such activities as reading (and re-reading), problem solving, case analysis, questioning fellow students (and the instructor), or even memorization.

Assessing Stability. No one is better qualified than the student himself to assess the stability and adequacy of his or her own learning in his or her areas of study. The student is best able to determine the frequency, methods, and conditions under which study should occur in order to learn meaningfully. However, educators typically evaluate such areas as participation, homework, exams, and even tardiness and neatness when assessing student learning. As a result, students gear study activities toward achieving success in these areas, in most cases at the expense of meaningful learning.

A more effective method for evaluating student learning would involve self-managed concept mapping (Novak and Gowin, 1988:93-103), and use of the V-heuristic (Novak and Gowin, 1988:111-118). This method provides a means of assessing the nature of student cognitive structures (concept mapping), as well as, their ability to construct knowledge and value claims (with the V-heuristic). Instuctors could supplement this with clinical interviews, projects requiring knowledge creation, and oral examinations (Novak and Gowin, 1988:128-133).

<u>Day-to-Day Operations</u>. With their unique perspective of the quality of learning produced by their various learning activities, the students are in the best position to manage day-to-day knowledge construction. Yet most students let the instructor manage it for them by acting only in response to threats of evaluation. If students managed their own day-to-day activities, focusing on areas where reinforcement is necessary, this would significantly facilitate the personal construction of knowledge. However, most students merely budget their time to meet deadlines for papers, projects, and exams; they pay little attention to

the effectiveness of their learning strategies, except as a means of achieving success in these areas.

Managing the Future. With all the emphasis placed on the "inside and now" of learning only what is necessary to successfully defeat typical academic measurement strategies, little time is available for assessing the "outside and then." Students are so preoccupied with achieving good grades that they budget little, if any, time for learning prerequisite material adequately for follow-on courses, or for their next job. The current emphasis on grades leads to students taking a short-term perspective of education. The disintegrated nature of many methods of education compound the problems associated with seeking long-term improvement (Ausubel, 1978:192-198).

If students struck a balance between studying for day-to-day activities and studying for the future, the advantages of meaningful learning (superior retention and facilitation of further learning) would become more apparent. Since meaningful learning facilitates retention and further learning, it offers an advantage over rote learning for long-term, integrative programs of study where students call upon learned material even after completing a course.

Recursion. The relationships among day-to-day operations and planning for the future for student learning are recursive, and also appear at the next highest level, the classroom. Just as the student is an operational unit in the classroom, the classroom is an operational unit within the academic program. In the same way that the student integrates the individual learning activities for his or her various classes, the classroom instructor integrates the learning activities of students in his or her class. Classroom activities are then integrated with other classrooms during a particular semester, and ultimately in a program designed to achieve an integrated learning set for a given degree.

Students cannot learn effectively without stabilty in the classroom. This can pose serious problems, however, since each student brings his or her own level of ability to acquire concepts. This results in a tremendous level of variability among the learners. Learning materials and the curriculum must be analyzed in light of this variety. For any classroom to succeed in producing desired learning outcomes, the learning environment must be capable of dealing with this variability of inputs.

The instructor serves as the director (manager) of classroom teaching activities (Ausubel, 1978:501). In the classroom, it is his or her job, by monitoring and manipulating the variables associated with learning, to facilitate the educating process. In addition, the instructor interacts with elements external to the classroom to determine the future possibilities open to the classroom. This ultimately leads to a need to balance the day-to-day management with the changes in the environment in order to keep the classroom experience viable and vital.

"The End of Educating". Once the student leaves the classroom, he or she no longer has an instructor available to manage teaching. Because of the explosion in technological advances, knowledge is increasing faster than ever before. Due to the resulting need for learning, present educational philosophy must be modified to keep pace with such a rapidly changing world. Current instructional methods which allow students to regurgitate large quantities of material (and then forget it) must be abandoned. Instead, students should be prepared to apply knowledge, and when necessary, acquire knowledge on their own. This requires focusing on the self-managed acquisition of concepts.

The greater the degree of self-management the student exerts in the classroom, the lesser the role of the instructor. Movement towards self-management diminishes the role of the instructor. While the instructor, by facilitating the learning process, may effect more efficient meaningful learning, the student will not always have the luxury of a structured learning environment.

When students leave the educational institution, they are out on their own. They now have the flexibility to pick their own teachers and curricula; they create and arrange their own learning materials. When research takes the learner to the very edge of what is known, a teacher may not even be available. In this case, the learner must take charge of his or her own learning. Out of the classroom, the student is no longer limited to simply effecting learning, but may become the manager for all activities associated with the creation of new knowledge (Gowin, 1987:195-197).

Achieving the end of educating will not be easy. In most cases, students are unaware of their responsibilities for learning, and simply do not know how to learn (Novak and Gowin, 1988:9-10). If the learning system requires a change in learning style of its students for effective learning to take place, then the system must provide instruction and training on how to learn.

The onus for improving any system falls on senior management. However, once a system institutes leadership for change and continuous improvement, everyone in the system must work to achieve quality for the program to succeed (Deming, 1988:86-88). Thus, the student must take the responsibility to seek further improvement.

Furthermore, an educating system could benefit not only from effective governance, but also from methods and technologies which improve collaboration and collaborative work.

Computer Supported Cooperative Work

> The elegant tools available now and in the future--superlative graphics, artificial intelligence services, and so on--only make sense in an integrated workshop of tools in which information may be exchanged. (Engelbart and Lehtman, 1988:246)

The tools which Engelbart speaks of are components of a computer supported cooperative work system (CSCW). CSCW refers to computer driven processes designed for amplifying collaborative efforts among workers. Computer hardware and software provide an organization with opportunities to improve collaborative efforts. In order to exploit these opportunities, special attention must be given to the way new technologies impact social and organizational areas. In addition, CSCW requires effective channels of communication, as well as means of organizing and storing information. The elements of a CSCW system are shown in Figure 2-9.

```
              COMMUNICATION
              /     :     \
             /      :      \
            /  INFORMATION  \
           /       SPACE     \
          /      /     \      \
         /     /         \     \
    HUMAN SYSTEM  -----  TOOL SYSTEM
```

Figure 2-9. Elements of a CSCW System

<u>Tool System</u>. The tool system portion of a CSCW system consists of hardware, software, and all the capabilities which come with them. The immense storage and retrieval capabilities of the computer; the computer's ability to compute, calculate, and transform records; audio; video; and communications are examples of tool system constributions.

Human System. The human system portion of a CSCW system consists of all factors possessing a human dimension which are required to actualize the tool system contributions (Engelbart and Hooper, 1988:20). Organizations must tailor specific computer technologies to meet organizational needs. However, an enterprise must consider the impact the computer has on the organization as well (Engelbart and Lehtman, 1988:246).

> If we use the computer simply to undertake a souped-up version of the old kind of control system, which was inadequate simply because we did not have computers, we are no better off than before. (Beer, 1981:16)

Simply stated, an organization must be prepared to change, and this need for change is inevitable. Organizations must adapt cultural and social factors to accommodate new technologies (Engelbart and Lehtman, 1988:252). Since traditional orthodox management approaches can prevent an organization from fully exploiting collaborative tools, organizations must evolve to accommodate new technologies (Zuboff, 1988:285-288).

The required evolution begins with the creation of a segment within an organization dedicated to identifying, creating, and maintaining capabilities which may benefit that organization. Once new capabilities are available, individuals must serve as change agents and introduce new techniques and technologies to the various segments of the organization. Finally, educational and training services must be established so workers may fully exploit the improved capabilities (Engelbart and Rheingold, 1988:14).

Communication. The human and tool systems in a collaborative environment combine to effect the sharing of information among collaborating workers. This makes dialogue a critical component of the system. Any collaborative system must contain tools for "reviewing, cross-referencing, modification, transmission, storage, indexing, and full-text retrieval" to support the exchange of information. In addition, communication involves support for activities ranging from electronic mail to large organized affairs such as conferences and conventions (Engelbart and Lehtman, 1988:246,249,252).

Information Space. The sharing of information is consummated by the creation of an information space which is shared among the collaborators. This information space contains various documents ranging from disposable electronic mail correspondence, to personal and collaboratively generated files. In addition, a CSCW system must have a method for tracking external documents so that workers remain abreast of current events. Within this information space, documents must be developed, produced, and ultimately controlled (Engelbart and Lehtman, 1988:249).

The Role of Hypertext. The ultimate goal of a collaborative effort is knowledge creation, with the sharing that takes place among the collaborators leading to learning. Companies are currently using hypertext, an exciting new technology, to manage the collaborative creation of knowledge. The workers at Knowledge Systems use KMS, a hypertext product developed in-house, to manage virtually all of their knowledge. According to David Akscyn,

> At Knowledge Systems we use KMS for almost every aspect of our work, including administration, product support, document production, product design and software engineering. (Akscyn, 1988:821)

Workers at MCC Technologies are currently using gIBIS, another in-house hypertext development, to support discussions and assist in organizing informal information (Conklin and Begeman, 1988:1). In addition, Owl's commercial version of Guide, a hypertext system, has extensive use (Brown, 1987:40).

<u>What is Hypertext</u>? The very nature of hypertext makes it useful as a collaborative medium. A hypertext is a network of interlinked modules of information. These modules of information, referred to as nodes, can be linked in a non-linear fashion using the unique properties of the computer. This non-linear linking presents information in a way that is simply not possible using two-dimensional paper (Marchionini and Shneiderman, 1988:71). Hypertext presents authors with a new and more flexible way to organize and structure information.

<u>Nodes</u>. Hypertext is characterized by modularity. Individual nodes are configured so they may be viewed through selected paths. Nodes may be arranged to

form the main text of the document (Yankelovich et al, 1988: 81), with reference information also placed in nodes and linked to the main text. Node contents are displayed in a window on the computer monitor screen; these windows can be manipulated on the screen and contain links which provide access to other nodes (Conklin, 1987:6-7). Linked references can be brought to the screen by either using keyboard commands or by using a pointing device such as a mouse, joystick, or light pen (Conklin, 1987:38).

Linking. Nodes may be arranged in any structure using links. The modularity inherent in a node-based document, coupled with the ability to link nodes, gives authors of hypertext documents a great deal of flexibility. Nodes may be linked hierarchically, effecting a non-linear presentation. In addition, by using special linking facilities, any node may be linked with any other node (Akscyn, 1988:828).

Hypermedia. "Hypermedia is simply an extension of hypertext that incorporates other media in addition to text" (Yankelovich et al, 1988:81). Hypermedia integrates text with graphics, audio, or video. Like hypertext, hypermedia consists of linked bits of information that do not follow a sequential pattern (Smith, 1988:32). These bits of information may be textual, pictorial, graphical, video or audio in nature (Yankelovich et al, 1988:81). As with hypertext, linking is the key aspect of hypermedia (Shafer, 1988:26).

Hypermedia offers new and exciting possibilities.

> Imagine, if you will, walking into the New York Public Library and picking up a book on Mozart. You begin to read and learn that Mozart was an Austrian composer in the late 1700s. You wonder what else was happening in Austria then, so you go to the card catalog, find a book on Austrian history, go to the stacks, locate the volume (if it's not checked out), and read it before you continue.
>
> In this book, you find a reference to old Salzburg, and you wonder what it looked like. Back to the card catalog, and the stacks, to find a book with images from that time. Finally, you get back to Mozart and read of a piano concerto you've never heard. This time you head for the library's record collection and listening room.
>
> This process continues until you have either satisfied your desire for knowledge on the subject or worn yourself out searching for it, whichever comes first.
>
> Now imagine sitting at your computer and bringing up a hypertext system on music. You begin to read about Mozart. When you wonder about Austrian history, you simply highlight the text and request more information with a mouse click or a few keystrokes. To find images of old Salzburg, you use the same process. And to hear the piano concerto? The same.
>
> Sounds a lot simpler, doesn't it? (Tazelaar, 1988:234)

The availability of audio and video in data files enables authors to incorporate multimedia presentations within hypermedia. Large hypermedia documents, known as hyperwebs, can yield rich presentations of information.

Browsing. Movement through hypermedia documents is referred to as browsing, and readers have several browse options available for moving efficiently through these complex information structures (Marchionini and Shneiderman, 1988:71). The reader can read whole documents, following each available node. Readers can also search through a hyperweb, following their curiosity, and focusing on key concepts while ignoring anything considered irrelevant. Finally, the reader can navigate using a map or outline (Conklin, 1987:6-7).

Advantages of Hypertext. Hypertext offers several advantages over conventional text.

Modularity. The modular nature inherent in a document consisting of nodes gives the author a great degree of flexibility. Document structures can be arranged hierarchically, non-hierarchically or both ways (Conklin, 1987:56). This gives the author the flexibility to handle concepts individually, then integrate and order them. Establishing and re-establishing the hierarchy of the document is handled by either creating or dissolving links between nodes (Conklin, 1987:54). This feature of hypertext is similar to what is involved in the creation and linking of concepts within the cognitive structure (Fidero, 1988:237).

Editing. The modular nature of hypertext gives anyone seeking to edit a document new and powerful tools. Authors can edit individual nodes just as they would edit any text file. However, authors can add greater levels of detail to a document simply by progressively adding more nodes to it. This capability is similar to the progressive differentiation of concepts which is required for meaningful learning.

With hypertext, authors can revise documents by simply adding or removing nodes from the main text structure. In addition authors can easily restructure a document by first unlinking nodes, then rearranging them, and finally relinking them to establish the desired structure. This function is similar to the shuffling and reshuffling of concepts within the cognitive structure (integrative reconciliation) which occurs during meaningful learning.

Linking a hypertext with a database containing many documents allows direct access to information contained within that database. This would eliminate much of the time and effort associated with research as actual text from the database could be rapidly accessed and subsequently included in the document being created. (Nelson, 1988:226).

Window Stacking. Some hypermedia products simply stack open windows on top of each other in the order in which their corresponding nodes were accessed. This feature, known as window stacking, makes it easy for readers to regain their place in a document after launching off and reading through several levels of nodes. The stack of windows on the screen provides a trail that readers may use to pick up where they left off; readers can simply close the windows, following them back to the point of origin. Window stacking provides an aid for orientation, as well as maintaining train of thought (Conklin, 1987:56).

Task Stacking. Another aspect of hypertext that eases reader workload is referred to as task stacking. Task stacking occurs when the reader simultaneously explores more than one trail through the text. This produces the same result as that observed when a researcher has several texts opened on a desk in front of him. The advantage of this over conventional texts, however, is that the reader can simultaneously view several windows within a single document (Conklin, 1987:56). This feature enables readers to maintain concurrent trails of thought, offering possible support for integrative reconciliation.

Disadvantages of Hypertext. Some of the features creating the tremendous advantages of hypertext also cause problems.

Parsing Undeveloped Trails of Thought. The advantage of modularity associated with hypertext requires greater levels of initial effort by the author composing a document.

> To use a hypertext system, you must get used to parsing your information into small discrete units, or nodes, which consist of a single concept or idea. In theory, nodes are both semantically an syntactically discrete. (Fidero, 1988:238)

It is generally difficult to separate thoughts into the individual concepts required for nodes (Fidero, 1988:244) and many times attempts to simply parse linear text along conceptual lines prove inadequate (Frisse, 1988:249-250).

The effort required to first compose and then separate text along conceptual lines, and organize and link concepts with other related concepts, is viewed as a major contributor to achieving greater levels of understanding (Por, 1987:15; Beeman, 1987:79-81). Unfortunately, the act of segmenting thoughts in this fashion serves to disintegrate subsuming conceptual trails (Begeman and Conklin, 1988:260). This can be especially destructive during early stages of concept formulation, when issues are not fully understood nor easily verbalized (Conklin and Begeman, 1988:16).

Increased Workload. While the workload of parsing text affects authors, the numerous paths available and the resulting choices that must be made in order to select a path of inquiry create an increased mental workload for anyone navigating a hyperdocument (Conklin, 1987:59). Increased workload is inherent in any media presentation which requires the reader to choose a path. In addition, workload can be compounded by means for analytical retrieval. Systems with such features can instantly transport readers to locations deep within the document--locations with structures which readers are unfamiliar with. Such systems can lack the coherence required for effective browsing (Marchionini and Shneiderman, 1988:71).

Disorientation. Mental workload contributes to the biggest problem with any hypertext system--disorientation. Disorientation afflicts both readers and authors as energy expended determining which path to follow is not available for determining the current location.

> There is thus a pervading need for navigation aids and also for checking aids that verify the validity of links. The need for such aids probably rises proportionally to the square of the document size. (Brown, 1987:39).

The need for navigational aids stems from the very flexibility which makes hypermedia so valuable. The complex structure of a hyperweb can lead the reader far from the main text of the document. Arduous navigation, coupled with the disorienting effects of high workload tasks, can cause readers to get lost (Conklin, 1987:59).

Hypertext is Difficult to Map. Disorientation can be alleviated somewhat by using pop-up maps that show the reader his or her location in relation to the local area, as well as the main path of the text (Smith, 1988:39). However, mapping a hyperweb is not a simple matter. This is due to the very nature of hypermedia. Since the multi-dimensional nature of hypertext is not easily represented using two- or three-dimensional graphics, computer generated maps are of limited use. On-going research is focusing on ways to decrease user workload, as well as provide more effective representations of hyperwebs. (Yankelovich et al, 1988:96).

Hypertext in Education. The Intermedia experience at Brown University demonstrated that working with hierarchically organized and linked materials in a hyperweb promotes a deeper understanding of course materials than does working strictly with linear text. Both instructors and students attributed this depth of understanding to the unique manner in which hypermedia demonstrates the interrelatedness of material (Beeman, 1987:77).

The interrelatedness of hyperweb presentations had profound effects on the classroom. Students felt the hyperwebs helped to "broaden and deepen their understanding of course materials" (Beeman, 1987:75). Once students could see how concepts relate to each other, instructors no longer dominated classroom discussions. Instead, instructors moved into the roles of classroom coaches (Beeman, 1987:75). One student felt the integrative perspective provided by the hyperweb helped him to learn how to learn (Beeman, 1987:77).

Collaboration. The students in the Intermedia experiment were quick to offer suggestions for improving hyperweb structures. Since "weaving large webs is so time-consuming that it can only be accomplished as a collaborative effort" (Por, 1987:16), this interaction between students and instructors ultimately lead to superior learning materials. In addition, participating students gained a better grasp of the course materials.

Construction. The main advantage of hypertext, however, lies in the ability it gives individuals to create and edit their own learning materials. In the Intermedia experiment, the builders of the hyperwebs reported gaining a better grasp of the material by trying to determine how to link various concepts (Por, 1987:15). While passive navigation through hypermedia documents enabled students to achieve broader and deeper levels of understanding, construction of the documents lead to even greater levels of understanding (Beeman, 1987:80).

III. Methodology

Chapter II showed how introducing new technologies to an environment can redefine that environment. Just as introducing air power to warfighting made trench warfare obsolete, introducing the computer to education will make the traditional classroom obsolete. Redefining the new educational environment begins with the question: what constitutes educating?

Using principles from educational psychology, the design effort begins by determining what the educational system is designed to do. The design effort can be made manageable by concentrating on three design levels for a college degree program: the student, the classroom, and the degree program.

Chapter II also pointed out educating (from student learning to integrating individual classes into a program of study) is a management-intensive activity. Keeping this in mind, the design effort must address the management activities which take place in educational institutions.

Design begins at the most important level where the most important work is done. In an educational system, the most important factor is learning, so the design begins at the student level. System design begins by addressing management of the personal construction of knowledge at the student level. Here, the quality characteristics which determine student learning must be defined to assure a quality educating system. Once these quality characteristics are known, the system may be designed to be robust to the variety it will encounter.

Once the student level has been designed for maximum learning, then the classroom level can be addressed. The purpose of the classroom is sharing, so the classroom is designed to provide maximum sharing. However, policies initiated to effect sharing must impose no more constraint than absolutely necessary.

The final design addresses the program level. The design criteria at this level involve integrating the educating efforts of various classrooms into a coherent program of study. Restrictions placed on learning and sharing must be no more than absolutely necessary to effect program integration.

IV. System Design

Efforts to design an educating system center around learning. The ultimate learning objective is subject mastery by the student. This involves maximizing retention and manipulation of concepts for given levels of effort. Subject mastery cannot occur without highly motivated meaningful learning.

The Student

Day-to-Day Operations and Feed-Back. Day-to-day operations for a student consist of integrating the knowledge construction efforts of several classes. Because of the need to balance their time between various areas, students need a method of assessing the depth and strength of their understanding in these various areas of study. In addition, students could benefit from methods to evaluate their ability to construct knowledge.

Planning for the Future. Choices made on a day-to-day basis produce long-term consequences. Education should provide students with the concept set required for performing various tasks in present and future situations. However, it is critical that students look to the future in order to continue to learn effectively. The learning system should not only maximize retention and concept manipulation of learned material, but also prepare students for further learning activities. The learning system should provide a link to the future by treating learning as a building process.

Management of Knowledge Construction. Each student has the responsibility for managing his or her own knowledge construction. Knowledge construction is a function of ten critical variables. These ten critical variables determine the learning process and instructional strategy a student chooses for a given learning event.

Learning Process. Meaningful learning is the preferred learning process for meeting the day-to-day and future requirements of a learning system. Concept manipulation is maximized through meaningful learning. In addition, if a task is potentially meaningful, and the student possesses adequate anchoring concepts to support meaningful learning, meaningful learning requires less effort than rote learning. To support meaningful learning, the learning system should provide means for hierarchic arrangement of materials, methods of progressively differentiating concepts, and facilities to support reconciling dissonant concept trails.

However, some tasks, such as learning the atoms in the periodic table of elements or learning definitions of terms, will require some rote learning. To accommodate such tasks, an effective learning system must accommodate the full range of learning processes.

Instructional Strategy. Meaningful reception learning is the most efficient method for acquiring vast quantities of concepts. For those instances where reception learning is preferred, the learning system must show the interrelatedness of the learning materials in such a way that the student acquires the curriculum materials meaningfully.

Meaningful reception learning demands the highest levels of cognitive development. Because of these demands, meaningful reception learning may not be possible for all students in a classroom. In addition, some students may prefer to function in a discovery learning mode. For these reasons, the learning system must support movement into the discovery learning domain. In order to support discovery learning, the learning system must provide means for students to build the learning materials themselves.

Internal Variables. During knowledge construction, the student manages five internal variables which include cognitive structure, developmental readiness, intelligence, personality factors (introvert-extrovert, intuition-sensing, thinking-feeling, and desire for openness versus desire for closure), and motivation. These variables, in turn, influence the learning process and instructional strategy. The relationship can be represented as shown in the equation below.

(learning process, instructional strategy) = f(cognitive structure, developmental readiness, intelligence, personality factors, motivation)

Cognitive Structure. Any learning involves adding concepts to what the student already knows. In order to maximize concept manipulation, the learning process must promote structured addition of concepts to student cognitive structures. Since some students may not have the appropriate anchoring structure to effect meaningful learning, the learning system must enable those students to create the anchoring structure. In addition, the system must provide methods for strengthening anchoring concepts, as well as methods of differentiating anchoring concepts from the concepts which students must acquire from the instructional materials.

Developmental Readiness. As with the cognitive structure, there is great variety among student developmental readiness. Some students may simply need a method for linking concepts which supports abstract logical reasoning. Other students, functioning at the preoperational level, may require methods which provide examples and illustrations from which concepts may be developed.

Intelligence. Intelligences vary greatly among students. In addition, Sternburg's notions of mental self-management of the triarchic mind suggest any learning system must support the practical, analytic, and synthetic intelligences of various individuals (Sternberg, 1988:55-60). Practical intelligence should be supported with an ample quantity of "real world" learning. At the same time the learning system must allow for the critical thinking abilities of analytic intelligence. Finally, the learning system should also provide means for exercising student synthetic abilities.

Personality Factors. As a result of varying temperament and character type, students possess a wide range of learning preferences. The designers of any learning system must acknowledge that most students learn more effectively when learning interactively. The learning systems must allow interaction and collaboration in support of this majority preference, while at the same time provide for individual study for those who prefer working alone.

The learning system must also accommodate the preference of the majority of students who learn more effectively when concepts are presented after the introduction of appropriate concrete examples. Again, the learning system must facilitate this process of concept introduction without oppressing those students who learn best from the conventional pedagogical practice of introducing the theory first, then following theory with examples.

The learning system must provide effective feedback for those students seeking approval and harmony, while at the same time fulfilling the needs of those students who must master and dominate subject matter.

Finally, the learning sytem must provide well structured learning tasks, with well identified checkpoints for assessing progress, in support of those students who need such aids to gage their progress. The system must also accommodate those students who learn best in an unstructured laissez-faire environment, where they are free to control their own learning destiny.

Motivation. Motivation levels determine the extent to which students exercise their cognitive capabilities. Subject mastery requires highly motivated meaningful learning. While the affiliative drive, ego enhancement, and aversive motivation can lead students to put a great deal of effort into achieving learning outcomes, these mechanisms all depend on factors external to the learning task itself. Cognitive drive, on the other hand,

> is probably derived, in a very general way, from curiosity tendencies, and from related predispositions to explore, manipulate, understand, and cope with the environment. (Ausubel, 1978:403)

Thus, cognitive drive requires no external influences, and is intrinsic to the learning task. In support of the cognitive drive, the learning system should provide students with effective means of exploring to satisfy natural curiosity.

One key to maintaining cognitive drive involves allowing students to follow their natural learning preferences. Restrictive classroom policies, which suppress student learning preferences, effectively prohibit students from learning as best they can. By making learning a difficult task, these policies deny students the joy of learning, and as a result, suppress cognitive drive.

External Variables. The student also contends with five external variables consisting of the learning task, instructor characteristics, the instructional materials, governance, and practice/review. While the student controls the amount of practice and review, the other four external variables are imposed on him or her. This point is important, since the learning task, instructor characteristics, developmental readiness, and governance all exert a great deal of influence on student selection of learning process and instructional strategy.

Learning Task. The potential meaningfulness of a task determines the learning processes available to the student. Some tasks, such as learning the letters of the alphabet, are not potentially meaningful. For such tasks, meaningful learning cannot take place.

Just as potential meaningfulness drives the learning process, current levels of knowledge determine instructional strategy options. One cannot receptively acquire the concept set of The Unified Field Theory until it is invented. Some tasks simply require rote learning processes, while others require discovery learning strategies.

Instructor Characteristics. Instructors are leaders and coaches in the classroom. Serving in this capacity, they require the communicative skills, as well as subject mastery, to effect classroom sharing. The communication required for sharing can be supported by an effective arrangement of the instructional materials. The instructional materials should contain a cogent and coherent concept set arranged for ease of comprehension by students. This sort of arrangement serves to augment the communicative skills of the instructor, as effectively arranged instructional materials communicate for him.

Instructional Materials. The arrangement of instructional materials determines the effort exerted in learning tasks. Ideally, these materials should bridge the gap between what the student already knows and the knowledge and value claims which make up the curriculum. When the instructional materials do not effectively bridge this gap, students will have limited ability to meaningfully acquire the curriculum materials without the help of the instructor.

To facilitate meaningful learning, the instructional materials should be arranged in a manner which demonstrates the interrelatedness of concepts. In addition, the learning system should provide a means of adding and differentiating subsuming concepts to the learning materials. This capability is required to support the building of anchoring and bridging concepts required to effect meaningful learning.

Governance. Governance is the force which brings together the student and instructor as they share meanings of the curriculum materials. The climate established will affect the learning level of recursion. For example, an authoritarian climate could restrict students from enhancing their learning experience by sharing among themselves. The system should allow extroverted students to cooperate to the extent necessary to promote effective learning. While conformity is usually seen in a negative light, if all students conformed to put in a great deal of effort, no instructor would complain. The learning system should seek to promote conformity as a desire to learn. The system should also include competition, but only to the extent that it promotes students to use their cognitive capacities, and not to the extent that competition becomes a disruptive force.

Governance controls the meanings, which in turn establish where effort is placed, in any educating environment. The variables of learning possess a great deal of variety. Governance dominates classroom learning to the extent that it allows or hinders knowledge construction by the students. Restrictive governance provides an environment to which the student must adapt his learning style.

Practice and Review. Student learning is reinforced through practice and review. Once a concept set is learned, students manage overlearning efforts (practice and review) in order to strengthen the links between newly acquired concepts and the existing cognitive structure.

The Role of Hypermedia. Hypermedia provides the ideal tool for assisting the student in creating links between what he knows and what he is learning. Hypermedia supports establishing a set of concepts and linking these concepts both hierarchically and non-hierarchically. This mimics the modular hierarchic nature of concepts arranged within the cognitive structure, and enables students to see meaningful relationships between concepts.

Effectively arranged multimedia presentations should enhance sharing. Bridges between what the student already knows and the curriculum materials could be built by navigating hyperwebs prior to lectures. Out-of-class review of effectively arranged presentations could give students the required concept set to effect meaningful reception learning in the classroom.

The learning system should enable students to create and add materials to hyperwebs in support of discovery learning. This capability also should enhance reception learning, since it requires students to first understand concepts, then place these concepts in their proper hierarchic position within the local cognitive structure. These are the very actions which constitute meaningful learning.

Hypertext provides methods for segmenting and rearranging concepts which both emulate and support progressive differentiation and integrative reconciliation. However, to be effective for student use, the learning system should support rapid editing.

With the ability to edit their own learning materials, students could adjust a hyperweb for the variety of cognitive development in a classroom. Because of its modular nature, hypertext enables knowledge construction workers to build the required support structures for present and future learning. By simply adding nodes, students have the ability to enact the structured addition of concepts to an existing hyperweb. This amplifies systemic variety for dealing with cognitive structure variability. In addition, students can develop the appropriate anchoring structure to effect meaningful learning. By adding nodes to a hyperweb, students can strengthen their understanding of anchoring concepts. In addition, students can better differentiate these concepts from those they must acquire.

By constructing multi-dimensional concept maps, students can create structures onto which they can place new concepts. Hypermedia presentations allow the student to effectively demonstrate the interrelatedness of various sets of concepts. Hypertext can thus demonstrate the relationships between what is already known and what is being learned in the same manner as these relationships are constructe[illegible] the student's cognitive structure.

Hypertext provides a method for presenting both what is known and what is being learned (the concepts in the existing cognitive structure and newly grasped and arranged concepts) in a manner that mimics the very relationships which exist in the cognitive structure as learning processes take place. For the system to be fully effective, however, students must have the ability to build upon existing webs so that they may personally construct knowledge.

Hypertext provides improved methods for presenting the structure of concepts required for meaningful acquisition of concepts and provides a picture to the student of how the knowledge is interrelated. In addition, multimedia presentations will assist students who are either unable or prefer not to deal with concepts, but instead prefer working with concrete reality before moving to concept manipulation. Effective multimedia presentations will serve to provide these students with a concept set which they can then employ in meaningful reception learning in classroom discussions. This can support sharing of information, not only between students and instructors, but also among students.

Hypermedia supports no-nonsense navigational facilities (for the practical student), complex methods of interactions and analytic retrieval (for the analytic student), and the ability to create and modify (for the synthetic student).

Feedback could be provided to students simply by allowing collaboration. Collaboration would support the learning preferences of those students who prefer interaction. In addition, it would give students feedback and enable them to correct misconceptions, as well as reconcile apparent dissonance. Stronger students could tutor weaker students, and students with various intellectual strengths could benefit from interacting with students possessing different abilities.

Collaborative work constructing hyperwebs is an ideal method for fulfilling the needs of students to learn interactively. Those who prefer to work alone can construct on their own, then enter their constructs into the hyperweb for review by others. In addition, collaboration would fulfill the needs of those students requiring approval, harmony, and a need to contribute. By making collaborative efforts difficult, instructors could help assure that students work together. In addition, projects requiring a great deal of effort should be included for individuals who have a need to prevail over learning tasks.

In the Intermedia experience, instructors found that collaboration is necessary for creating hyperwebs. Instructors should enlist the aid of the students and take advantage of student learning while at the same time conduct reconciliative maintenance to hyperweb structures.

Hypermedia also supports working with interactive learning materials. Effective learning materials should include interactive programs which students can call from within the hyperweb. At the same time, interactive programs also support the needs of those who prefer to work alone.

Just like conventional text, hypertext contains facilities to support dealing with highly conceptual material. However, hypermedia presentations, with illustrations and interactive graphics, can effect presentation of examples which support the learning styles of those who prefer concrete reality, or are unable to function at the level of cognitive development to support highly conceptual meaningful reception learning. In addition, by giving students the ability to create and add textual, as well as multimedia presentations to hyperwebs, the learning system should accommodate synthetic intelligence.

By including concrete examples in a hyperweb, students with a preference for moving from the concrete to the conceptual will cultivate the concept base required for meaningful reception learning. This, in turn, will provide students with a greater ability to acquire concepts, as well as the capacity to acquire concepts more quickly.

The learning system must also contain a well arranged set of learning tasks, since half of the students have a pressing need to know what is expected of them. At the same time, the learning system must also support the needs of those students who learn best in a laissez-faire environment.

The cognitive drive can be supported by providing hyperwebs with more than enough nodes to satisfy student curiosity. Further support can be provided by enabling and even requiring students to create structure in the hyperwebs. The Intermedia project clearly showed that many students are willing to suggest improvements to hyperweb structure.

In addition to focusing on the augmenting technologies, the educational system must address the human system. Both students and instructors must learn about learning. Students must be shown their resposibilities as knowledge creators. Instructors must know how to share the curricula and construct effective learning materials. Everyone must be trained.

One requirement which must not be forgotten for any computer supported educational system is transparency of the computer. The majority of computer applications created by researchers fail to reach the market. This is because they do not integrate with other software, and are not user friendly enough for use by anyone except those who develop them (Brown, 1987:39).

The Classroom

It is in the classroom where sharing takes place; within the classroom, the student is the operational unit. Sharing enables the student to grasp meanings. Once the student has grasped the shared meaning, he takes over and penetrates to the next lower level of recursion to construct meaning. The instructor, through the sharing process, serves as a stabilizing force in the classroom.

Sharing and the Instructional Materials. Sharing is mediated via the forces which control the efforts involved in student-instructor interactions. The instructional materials should therefore be arranged in a manner which both facilitates this sharing and enables construction of knowledge. This can be done by showing the interrelatedness of concepts.

Just as the student is obligated to learn in order to facilitate future learning, the instructor must assure effective sharing so that future sharing is possible.

Effective learning by the student at the student level of recursion supports future sharing. This relationship is reciprocal--sharing in the classroom promotes student learning, while learning enables students to share. Thus, effective sharing, which promotes construction of meaning, in turn promotes sharing for tomorrow. Those factors which govern sharing should be designed to support sharing in the classroom.

The Impact of Constraints. Design characteristics imposed at the classroom level decrease the variety available to the student for constructing knowledge at the learner level. Therefore, the restraint imposed at the classroom level should be the minimum required to effect sharing. In addition, variables assigned at the classroom level impact the quality characteristics of the learner, who is a student at the classroom level. Characteristics imposed at a higher level of recursion become constraints to the systems nested at lower levels of recursion (Beer, 1979:173-175).

Any system for learning in a classroom setting must consider the sharing that takes place. The learning system must facilitate sharing. In addition, it must provide a means for the instructor to be able to recognize the extent to which the student has grasped meanings. The instructor must also be able to determine how well the learner understands newly grasped concepts, and how well the student can differentiate between concepts which are similar.

Day-to-Day Management in the Classroom. The instructor manages the day-to-day activities in the classroom, and needs a method for both assessing and providing stability for the sharing function. The learning system should facilitate instructor analysis of the level of variety of sharing outcomes and provide for adjustment on the part of the instructor if necessary. In addition, a learning system must provide a firm foundation for future sharing for both the future presentation of materials within a class, as well as across classes within a specific course of study.

An ideal learning system would provide a method for instructors to take a snapshot of the students' cognitive structures to assess the degree of learning which has taken place. In addition, such a system would provide for assessing learner ability to manipulate those concepts mastered.

Any new learning system must avoid the current premium placed on short-term performance (at the expense of long-term concept manipulation and retention). The current system of assessment is also used to rank students for assessing relative ability. While this seems like a good idea, accomplishing multiple objectives with a single task, it does not account for systemic variability. Only those students outside the system deserve management attention

(Deming, 1988:318-322). The rest are simply performing as expected, and any methods of differentiation are virtually meaningless.

The process must also consider the characteristics of the instructor. Properly arranged instructional materials improve the ability of the instructor to communicate with the students, and thus enhance the ability of the instructor to share. In addition, arranging materials such that concepts are presented at their proper hierarchic level, and only after appropriate anchoring concepts are first presented, reinforces the pedagogical competence of the instructor.

The system should reinforce instructor knowledge of subject matter by providing alternate sources of cogently and coherently presented concepts to supplement classroom lectures. This type of presentation, which would allow students to explore the material on their own, could possibly serve to foster cognitive drive, preferably by supporting student curiosity with on-line access to supporting material.

The classroom exists as a forum for sharing between instructors and students. To this end, governance should provide no more restraint than is necessary to effect sharing. The overriding concern of the classroom should be the meaningful acquisition, by the students, of those knowledge and value claims which make up the curriculum.

Students are knowledge construction workers; governance should in no way prevent them from doing their job.

Governance establishes what is acceptable and unacceptable in the classroom. The climate established through governance will control the amount of competition conformity, and collaboration occurring in the classroom. To the extent that the various factors which governance controls contribute to effective learning by the students, governance should provide restrictions which enhance the learning process. However, governance should never restrict students in their quest to construct knowledge from the learning materials.

Governance is necessary to the extent that a program must provide a unified concept set for the various classes which purportedly integrate into some coherent whole. This unified whole should contain common value and knowledge claims which have been deemed necessary (or at least beneficial) for a given field.

The Teacher as Leader and Coach. Management in the educational arena is different than that of other areas. Like an effective supervisor, an effective instructor must "motivate his troops" to get the best out of them. Unlike an office manager, who can micro-manage inferior subordinate output by redoing it himself, in the classroom, the instructor cannot redo the work of the students--he cannot learn for them.

At the classroom level of recursion, management actually resembles coaching. Like an athletic coach, an instructor cannot "take the field" and "do the job" of learning. Students, like their athletic counterparts, are the only ones who can get the job done. This makes the classroom management skills of the instructor critical to effective learning. The effective instructor, like an effective athletic coach, must provide students with the skills for acquiring knowledge, and do his or her best to assure students remain motivated.

The Instructional Materials as a Bridge. At this point it is critical to determine the possibilities for exploiting non-linearities which might render the learning system robust to variety of instructors, instructional materials, and governance. These non-linearities must serve to impose minimum constraints, while increasing the variety of the learning system to cope with the variability of the quality characteristics. Thus, the system must provide minimum constraints, yet effect sharing.

Once instructors become part of the classroom, instructor characteristics become relatively fixed. However, the instructional materials can augment the sharing process of an instructor, simply by providing cogent and coherent subject matter in an easy-to-comprehend fashion. In addition, "living" instructional materials which students can tailor to suit their learning preference would further improve learning.

One of the most significant factors driving any knowledge construction process is the grading policy. To truly effect learning, grades must be eliminated. Grades prevent continuous improvement and destroy constancy of purpose; grades tend to promote short-term perspectives.

Learning at the classroom level can differ drastically from autonomous learning, since the constraints imposed by the instructional materials and instructor characteristics, coupled with grading policies, may drive students to rote reception learning in order to achieve the short-term success demanded by current grading policies.

Educational Program

The educational program is interested in assuring that work from individual classes integrate into a coherent program of study. To this end, individual classes are producing units in a program of study. The school administration must assure the various courses integrate in order to effect a coherent whole. The educational program requires a method for assessing the comprehensiveness and integration of individual courses into a program of study. In addition, the program directors must assess the product of the program, the student, to determine if the program is meeting its objectives.

Learned material serves two critical functions in education. The first is for use, i.e. linear programming techniques learned in an operations research course might be used in an accounting course to find an optimum mix of products. The second is as a foundation upon which further knowledge is built, i.e. the first course in a two-course statistics sequence serves as a prerequisite for the second.

Interaction With the Environment. At the program level, governing program directors interact with the external environments with which graduates will interact in order to determine the requirements for present and future learning.

Governance at the program level has far-reaching impacts on lower levels of recursion. Policies established at the program level (i.e. grading policies, number of courses per semester, allowable electives, number of courses in the program, the duration of the program, etc.) impose constraints on both the classroom and the student. Thus, both the classroom and the student must adapt to these policies. Because of this, governance at the program level must provide the minimum constraint required to effect an integrated program.

The ideal learning system balances day-to-day learning activities in such a way that the student does not "burn his bridges" for future use of material learned. The ideal learning system thus provides a method of executing day-to-day learning tasks which promotes long-term retention and manipulation of learned material.

The student needs to apply a unified concept set (possibly an isolated island of concepts) in follow-on courses. By establishing relevance for all course work, i.e. requiring the use of learned material in follow-on courses, any short-term advantages of rote reception learning are r[illegible]ted by the amount of rework required to re-learn forgotten rotely-learned concepts. This waste hits students smack in the center of their most precious commodity--time. The most significant constraint which governance could impose at the program level is relevancy--course work in early courses must be relevant to comprehensive follow-on courses which require previously mastered skills and concepts.

A hyperweb could provide an effective means of assessing the interrelatedness of the various inter-course curricula. The creation of program level hyperwebs could help instructors assess the relevancy of their course work to a given program of study. By assessing the interrelatedness of curricula from the various courses, program managers could determine whether the appropriate material was being included in a course.

Higher Management Levels

Higher management levels impose governance, which like the governance imposed at the classroom and program levels, constrains student efforts to construct knowledge. Policies such as grading requirements, research requirements and other policies generally dictated for accreditation purposes must be re-examined in light of the devastating effect they currently have on student learning.

V. Conclusions and Recommendations

Informating technologies and strategies currently available for use in the TQM program could have a significant impact on creating the quality culture sought by the DoD. Exploiting these technologies and strategies requires a great deal of educating. However, present educational methods do not promote the personal construction of knowledge required to take advantage of informating strategies.

Computer technology offers to revolutionize education and provide the much needed improvements for learning. However, this revolution will not take place if educators simply insert the computer into the current classroom. Instead, efforts must center on rebuilding the entire educational system around the computer. This rebuilding process involves not only understanding computer capabilities and educational psychology, but also the management of educating.

Educating is a management intensive activity. An educating system may be designed by addressing management actions at the student, classroom, and program of study levels of an institution. By looking at how computer technology impacts management at these three levels, the present educational system can be redesigned to accommodate the computer.

Redesigning the educational system to accommodate hypertext presentations offers a great deal to classroom learning. This stems primarily from the way hypertext can be arranged to show the interrelatedness of material. Interrelatedness is at the heart of meaningful learning, and subject mastery requires meaningful learning. Hypertext shows the interrelatedness of material by mimicking the very structure used within the brain to associate concepts.

Conclusions

Educators can exploit hypertext by using it to arrange instructional materials for classroom use. By creating hypertext knowledge-bases, instructors can provide students with materials arranged in an easy-to-comprehend format. Such effective arrangement supports the instructor's ability to communicate by providing an effective medium for showing how various concepts are related. By supporting the instructor's ability to communicate basic subject-matter, students can be better prepared for class, where instructors can use class time for sharing difficult material with the students and clarifying misconceptions.

The effectiveness of a hypertext can be enhanced by including interactive multimedia presentations. Multimedia presentations support the different learning preferences, capacities, and intelligences of the various students. The resulting hyperwebs are variety amplifiers, and enable a greater number of students to understand the concepts presented in the learning materials. Presenting multimedia examples of concepts located in the text also supports the cognitive drive by allowing students to satisfy their curiosity.

While arranging subject matter using a hyperweb for navigation by the students is an effective method for introducing students to subject matter, the actual construction of hyperwebs effects greater levels of learning. The actual construction work involves not only understanding various concepts, but also seeing how concepts are related to each other. Greater levels of understanding are achieved by differentiating between various concepts. Ultimately, concepts are rearranged when students see new relationships between what they know and what they are learning.

Creating a hyperweb involves a great deal of time and effort. By allowing students to work together, instructors not only get a better more useful product, but also fulfill the needs which most students have for interaction. The resulting collaboration will produce more effective learning for all students involved.

Since creating a hyperweb is a difficult task, student inputs can be fed back into the instructional materials. This not only contributes to the quality of the instructional materials, but actually leads to the instructors learning from the students, as students present perspectives which the instructors had never considered before.

Student contributions to construct hyperwebs will be limited if the linking and reshuffling of the node structure is not easily accomplished. For students to contribute effectively, and get the most from the learning experience, the computer must be transparent to those using it. The emphasis in any educating environment is on learning; using the computer must be easy. This requires a user-friendly environment, as well as effective training on how to use the computer.

Knowing how to use the computer is not enough; students must also know their roles and responsibilities associated with learning in the classroom. Furthermore, they must understand how learning relates to the other three commonplaces of education, and how all the commonplaces interact. This is necessary in order to effect any changes to the educational system.

Once students understand their responsibilities, they must be taught to manage knowledge construction. This requires not only understanding the variety inherent in knowledge construction, but also how to manage that variety. However, students are currently so caught up in managing day-to-day activities in search of the highest grade for a given amount of work, that subject mastery is no longer considered an objective. Students cannot be allowed to get so caught up in satisfying auditory objectives that they lose track of the ultimate goal of educating. The emphasis on grades promotes short-sighted perspectives as students manage academic efforts to achieve desired grades, and not to master subject-matter.

Establishing and maintaining a quality system requires a commitment to continuous improvement. Students must be trained not only how to manage their knowledge construction, but also how to effect continuous improvement to the educational system. Improvement is the responsibility of everyone.

Once everyone knows his or her responsibilities, how to manage his or her day-to-day efforts, how to effect improvement, and the role of the computer in education, then an effective hypermedia-based system can be instituted.

Students, instructors and administrators must be trained as to their roles and responsibilities in the educational environment. This training must include educational theory, quality training, a basic understanding of the computer (and the role it can play in effective educating), and finally, a strong enough understanding of management cybernetics to effect efficient control of the academic environment. Students must understand how to manage knowledge construction, teachers must understand how to manage sharing, and program administrators must understand how to manage an integrated program of study. This is especially critical in the ever-changing high technology world in which we live.

One neglected area in education is the feedback loop for assuring effective sharing in the classroom. This shortcoming can be overcome by establishing quality circles in the classroom. With the appropriate management support, quality circles, made up of students, can provide the required feedback to instructors on the effectiveness of sharing in the classroom.

To overcome the lack of feedback at the program level, quality circles, made up of instructors from the various classes making up a program of study, should be established. This could help to overcome the disintegrated nature of programs of study.

Suggested Future Research

Prior to entering a program of study, one term should be used to instruct students in the areas of educating, management, quality, and use of hypertext.

The material on educating should include the constructivist, assimilative notions of David Ausubel. In addition, the curriculum should include a study of the four commonplaces of educating as described by Gowin. While emphasis should be placed on learning, students must fully understand how learning relates to the other three commonplaces in effective learning environments.

The management required for the effective construction of knowledge demands greater and greater abilities to deal with variety. Students cannot deal with this variety without an understanding of how to manage it.

Once students understand how to manage their learning, they can look at ways of improving the learning system.

This requires an understanding of quality. The curriculum should include a study of the 14 points of W. Edwards Deming. Deming's 14 points provide a roadmap for instituting a program for continuous improvement.

With a firm understanding of educating, how to manage the construction of knowledge, and how to continuously improve the knowledge construction process, students are ready for the tools to effect improvement. KMS provides a hypermedia environment which supports text, graphics, and programs. KMS is an appropriate tool for creating an integrated knowledge base modeled after the actual construction which takes place in the cognitive structure.

Providing the students with the tools required to create an ever-improving learning system will be useless without management support. Before the quality culture can take hold, everyone must know his or her responsibility in creating a quality learning environment. This means everyone, from the dean on down, must be made aware of his or her responsibilities for creating a quality learning system.

All instructors and administrators must receive the same training as the students. Everyone must be aware of his or her responsibilities in the educating system. In addition, everyone must also know how to effect continuous improvement, as well as how the computer plays a key role in improving the educational system. Finally, everyone must understand how to manage the variety at the various levels of the educating institution, as well as the impacts decisions made at higher levels of recursion have on the learning process.

With proper management support, quality circles can be established for individual classes. This provides students with a channel for giving much needed feedback on the effectiveness of instructor efforts to share. This, in turn, can lead to methods which make sharing, and ultimately, learning more effective.

Quality circles should also be introduced for the various programs of study. These quality circles should consist of instructors from the various classes which make up the program. These instructors can work together to make their course-work content relevent to the program as a whole.

Introducing KMS to the educating system should begin with buiding a hyperweb for use in teaching a class. Based on the lessons learned, hyperwebs should then be constructed for all the classes included in a program of study. Working to integrate the various classes into a coherent whole can lead to the creation of a single integrated hyperweb which contains the learning materials for an entire program of study. The hyperweb could be expanded to include elective material, as well as material from other related programs of study, which could be relevant to the learning experience of the students. This hyperweb would contribute not only to the integration of various segments of the program, but also could serve as a tool for evaluating the relevance of the content of various courses.

Finally, grades should be abolished. They serve little useful purpose in determining the effectiveness of individuals leaving the academic environment, and only lead to a short-term perspective on learning.

These recommendations may appear revolutionary, but are no less startling than the benefits which may be derived from their adoption. Freedom from the stress of restrictive policies will allow students to explore and satisfy their natural desire to learn. In addition, the resulting system, which is robust to learner variety, will enable this force of highly motivated knowledge construction workers to do their jobs to the best of their abilities.

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This thesis proposes the design for an educating system which is robust to student variety. The design is founded on educational psychology, with quality principles playing a major role in establishing the design criteria. Since educating is a management-intensive activity, management cybernetics also play a key role in the design.

The need for an effective educating system stems from ever-increasing requirements for learning. The Total Quality Management (TQM) program, a Department of Defense (DoD) initiative geared towards providing quality weapon systems, promises to be a learning-intensive endeavor. The Japanese have shown quality requires extensive training and continuous education. For a quality culture to take hold, all DoD members must be educated about quality. In addition, computer technology can play a major role in transforming the DoD. Before the computer can be used effectively, however, workers and managers must be made aware of the possible benefits.

The need for an effective educating system stems in part from the need to educate workers about quality techniques and computer technology. At the same time, both quality and computers offer to revolutionize educating systems. A computer-based learning system, founded on a quality design, will not only meet student needs, but will also contain features to assure continuous systemic improvement.

The proposed design solution centers around a hypermedia-based, computer-supported collaborative system. While research stems from the need for effective means of educating the workforce about quality, the design solution is not limited to any particular subject. Recommendations for system development follow the design solution. These recommendations lay out a plan for integrating individual courses into a cohesive program of study.