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Commentary

Can Educational Technology Theory and Practice Benefit from Systems Analysis?

P. David Mitchell

INTRODUCTION

The purpose of this paper and the research that underlies it is to identify and introduce several planning and decision-taking technologies for both educational researchers and practitioners of educational technology. Not concerned with specific problems or detailed solutions, it examines classes of problems that are common to operational research in complex systems. Educational technologists, to say nothing of other educators, seem unaware of various recurrent phenomena in the problems and systems they study, phenomena that appear to be operative across system levels. Theoretical understanding of such recurrent processes is valuable whether we are concerned with designing and managing a national education system, a small learning resources centre, educational materials production, or other educational system.

The essence of technology and therefore educational technology is knowledge about relationships (e.g., if we perform action X, there is a probability, P, that outcome Y will occur). But it seldom is clear which action X is most likely to produce the intended result Y. Systems research often may help us clarify our decision-making.

LIFELONG LEARNING IN AN AGE OF TECHNOLOGY

This paper is animated by a concern for education, not simply for classroom instruction. More than half the world's children are *not* in school and the global need for . education has been rising. This forces us to refurbish our ideas about how to implement educational aspirations, as well as to augment existing educational manpower. Perhaps more important is that school costs (in both affluent and penurious nations) rise even more rapidly than enrolments or national incomes. We face an inevitable conclusion, "Les fails s'imposent done avec une evidence irrefutable: aucune pays au monde n'a les moyens

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d'assurer par I'ecole seule 1'education dont sa population a besoin" (Gerin-Lajoie, 1971, p. 5). The social ferment of contemporary society no longer permits the luxury of educational research devoted more to personal satisfaction than to improving the welfare of mankind.

Most individuals in the world are deprived of access to stored human experience-ideas, knowledge, skills and opportunities to acquire them. Such deprivation (because no one can afford to provide them) should be morally repugnant to the educational researcher. To make matters worse, only those persons and nations who develop educational autonomy are likely to avoid self-destructive activities. Adaptation calls for continuous education of all members of society. Thus education (as the optimal organization of personal and social development) implies continuity from its genesis at a parent's knee to death. This functional necessity is not limited to institutions organized to provide instruction. Nor is the needed research limited to traditional manifestations of educational research.

THE SCOPE OF EDUCATIONAL TECHNOLOGY

As an emerging field, educational technology may serve as the nexus of educational research and arrangements for fostering lifelong education. Educational technology embraces a fivefold conceptual mosaic of core meanings: Psychotechnology; Information and Communications Technology; Organizational Technology; Systems Technology; and Educational Planning *(cf.* Mitchell, 1975; 1978). Educational technology has become an area of study and practice concerned with all aspects of the organization of educational systems and procedures whereby resources are allocated to achieve specified and potentially replicable educational outcomes. Educational technology is an intellectual and practical pursuit, not a stable product or machine. The theoretician asks: How are educational processes and systems organized? What resources are needed to produce valuable outcomes? The practitioner asks: How must Education be organized so that the maximum benefits of personal and cultural development can be enjoyed for each expenditure of effort and resources? — a basic educational question and one open to continue philosophical analysis, objective research and pragmatic compromise. As a problem solver, one's methods, techniques and tools, as well as his knowledge and values, are derived from many spheres of activity. Educational technology thus requires educational research, albeit of a different kind than that presented in the typical textbook and critically examined by Bernard (1986).

It is pointless to debate whether current educational technologists are too concerned with the interface between the individual and the structure or content of a subject. Education is conceptualized as occurring within a set of systems within systems which range from one person to mankind's collective intentional organization of educational opportunities. Educational technology stands as a bridge between educational requirements and resources, between theory and practice, between a just, educative environment and cultural evolution. And intellectual technologies such as systems analysis, which translate desired outcomes into plans for an operational system, can build such bridges as readily on the scale of national educational requirements as in organizing instructional subsystems. What matters is that all relevant knowledge and skill be directed to the task of producing good decisions and more effective solutions to applied or theoretical problems. We must not prejudge the best approach to a particular decision.

EDUCATIONAL RESEARCH AND OPERATIONAL RESEARCH

Educational research typically is represented as a scientific investigation of events considered important to education. An important purpose is to provide theoretical and practical knowledge about human behaviour which can be used to make education more effective. Emphasis is placed on problems associated with producing changes in a person's capability and a concern with refining our scientific understanding of instructional processes. Experimental investigations permit testing of presumed relationships in a restricted setting. We need another approach to deal with lifelong education within and without current institutions.

Applied educational decisions and systems development or management lack the precision and control of a laboratory, involve many variables simultaneously and usually include several — often conflicting — objectives. Further, we need solutions to operational problems qualitatively different from that of the classroom. Improving the effectiveness of education may be achieved not simply by improving instruction but by addressing molar questions that subsume an interrelated pattern of many variables. Nowhere is this more necessary than in considering lifelong learning through inter-play with myriad educational opportunities (e.g., schooling, social and community organizations, vocation-related activities, public media). But it is equally important in using educational systems as instruments for improving educational effectiveness. We need research models that help us to understand, predict, explain and perhaps control human behaviour. Although this applies equally to the student, who needs control his own educational behaviour, what follows is limited to organization and management of other people's education.

In order to avoid misleading discussion we shall not consider unplanned or unanalyzed educational opportunities (e.g., conversation, personal investigations, visits to museum or theatre) which can be exceedingly important for personal development. However, operational research is applicable to investigating such complex problems in order to guide the policy and actions of educational planners. Here we examine tools applicable to common problems of analysis or synthesis. Their use in specific situations may be expected to yield general principles for educational theory.

System Analysis

System analysis is little more than a fashionable term to describe the employment of scientific knowledge, methods, techniques and tools to solve complex planning problems involving the direction and management or allocation, of resources (peoples, materials, money, time) to achieve desired outcomes. Operational research (OR) is distinguished from traditional educational research by its emphasis on system analysis of ongoing operations at a molar level. Phenomena can be investigated holistically in all their multidisciplinary aspects. Description, analysis, explanation and prediction of system behaviour using OR theories and procedures provides a scientific basis for solving problems involving a complex of interrelated entities. It does so in the best interest of the organization as a whole and its clients. Such systems research supplements other educational research.

OR transcends traditional disciplinary boundaries in its focus on the function and structure of a system to obtain information to guide policy and operational decision. To describe a process or complex of interrelated entities typically requires construction of some kind of representation or model of it. We can predict and compare outcomes of alternative strategies or explanations which might obtain with the real system by conducting experiments on the model. OR has produced a number of theories and models that describe recurrent processes which exist in a wide variety of systems. Seemingly diverse phenomena can be described by mathematical or computer models that portray key structural and functional factors. The disciplinary characteristics of the system are unimportant to OR theory.

Identification of classes of educational problems in terms of their amenability to systemic analysis has hardly begun. But the impact for educational research and future practice of educational technology is sure to be profound. No matter what one's sphere of operation, several OR models have the promise of educational application. Here is an introductory description with, however, no attempt to set forth quantitative and computer procedures.

DECISION THEORY

The essence of educational technology research and development is that: the practitioner has a problem with a desired outcome (perhaps several); there are at least two courses of action possible; the decision occurs in a context; and a state of doubt exists over the best activity to select. Some of the variables can be controlled by his decision, others cannot (though they may be controlled by another person). Decision theory permits one to solve a simple problem by constructing a model (based on a verbal problem formulation). The model might be physical, graphic, statistical or algebraic. Note that each of these involves a conceptual model. Analysis of the model permits decision taking to proceed and the solution thus derived is tested and implemented. The aim is to select the most attractive course of action.

Simple, especially repetitive, decisions can be taken easily using a decision table, decision tree or simple algorithm. The efficiency of a course of action is the probability that the action will yield the intended outcome. The relative value of any outcome may be determined by a relatively simple procedure outlined by Churchman (1961).

Atkinson (1971) was one of the first to provide a decision-theoretic analysis of instruction. He hoped to provide an optimal instructional strategy by examining : possible states of nature; alternative courses of action open to the person that may change the state of nature; the resulting alternation; and the cost and benefit resulting from each decision. But this model (reminiscent of Ackoff, 1961) calls for a model of the learning process somewhat more sophisticated than many now in existence. (For a computer simulation model to investigate instructional decisions, *cf.* Mitchell, 1973.) Further, in some cases it may be more appropriate to consider nature and other people as competitive decision takers rather than passive systems. Here game theory might be the more helpful conceptual framework even though this is as yet impractical for planning education. (Game theory is not to be confused with educational games that seldom are linked to this formal theory.)

QUEUEING THEORY

Although operational research has yielded many techniques to facilitate decision taking under conditions of uncertainty, one model is salient. The bottleneck problem — too great a demand for immediate access to educational resources — pertains to information retrieval, educational channel capacity, idle production facilities or students arriving at a self-instruction centre. These recurrent waiting line processes are explained by a queueing model which provides an optimal number of service facilities to keep waiting times within acceptable limits. Queueing theory is likely to provide useful explanatory models for many educational processes. However, it is especially useful when we must design and manage many similar services (e.g., self instruction systems; institutions) in which the same procedure can be used to analyze each planning problem even though specific details vary from one installation to another. It is indispensable if we must plan a system to cope with predicted demands for service by recommending the number and capacity of very costly facilities.

A queueing problem involves balancing the costs involved in a system which could have too much waiting time on the part of users (input) *or* service system (idle process time). With a shortage, or inefficient use, of facilities, a queue of arrivals builds up -- a familiar process. But a queue of idle or wasted time on the part of the *server* process occurs with insufficient input demand. With scarce funds, idle service facilities for self-instruction are undesirable.

Education systems are replete with illustrations of queues. The educational cost is difficult to estimate but lost opportunities can be identified as a major cost to society. How can we determine the optimal organization of educational services or facilities to provide acceptable service at an acceptable cost? Redfearn (1973) shows an application of queueing theory as a course design tool, given fixed service capacity service. But how can we determine what is needed to serve a given number of students? Let us illustrate the main ideas.

First we must recognize that a queueing system consists of the processing system and the queue of arrivals. Suppose a learning centre is expected to serve 100 persons who may come at any time during a 15 hour day and each will use a self-instruction facility for an average of 20 minutes (depending on remedial sequences or early departure). How many self-instruction media units will we require? To answer this we might wish to know the average length of the waiting line, the average waiting time, the percent of the time the queue holds one, two, etc. persons, the longest waiting time or percent utilization of the service. Intuitively each unit could handle up to 45 users per day (3 per hour x 15 hours) so three units handling up to 135 users seems adequate. But application of queueing theory, using a simple approximation technique, shows that a problem could arise. Suppose the arrival rate, AR, is 7/hour and service rate (with three units), SR, is 9/hour. The average length of the queue, QL, is *approximated* by:

$$QL = \frac{AR}{SR - AR} = \frac{7}{2} = 3.5.$$

$$\text{The maximum time waiting, } WT = \frac{AR}{SR(SR - AR)} = \frac{7}{18} \text{ hour} = 23 \text{ mins.}$$

How many clients are likely to wait that long for a 20 minute programme, especially if this is a service to out-of-school users? If we try four units, expected QL is 1.4 and WT = 7 minutes; five units reduces QL to .88 and WT to 3.5 minutes. Armed with capital and operating costs we could now decide the best capacity for this system. A similar approach could suggest the number of channels required for ETV on demand or provide a model of an individualized instruction system.

It should be noted that this is a crude approximation. It assumes random arrival rate and random service time and approximates a multi-channel service by a single server. Other assumptions require different approaches. Computer simulation of the system may provide more accurate information and is worth the effort in many situations. But even a crude approximation is better than an unfulfilled wish.

In applying queueing theory, variations in arrival and service rates by time of day or year (e.g., typical *versus* peak demand) can be taken into account as can be expected events (breakdowns, budget changes). Further, self-aggravating queueing situations can be turned into self-improving situations by minor technological or organization changes (e.g., scheduling users or service, providing an alternative to unproductive waiting time). Finally, most queueing systems consist of multichannel, multiphase components, varying priority rules and other complexities. Though these prohibit analytical models they can be studied using computer simulation models. Often a single measure of managerial effectiveness may emerge which otherwise remains elusive. For instance, problems of decentralizing *versus.* pooling facilities may be analyzed in this way. Thus queueing theory is a useful analytical and planning tool for educational research.

MARKOVIAN PROCESSES

Many systems can be described by discrete variables because the result of a decision or change in system state is not continuous (e.g., a behavioural objective is met or it is not; a student chooses one learning system over another). Often we want to know how a system makes a transition from one state to another or to forecast future system states. Markov analysis provides a way of analyzing the current state of a system to calculate the probability of particular transitions and rates or progress through a sequence of states.

The term, Markov process, refers to a mathematically definable sequence of system states in which the state of a system at some point in time does not uniquely determine subsequent system states. Rather they present state determines only the probability of future developments. To illustrate, one can analyse learning as a process whereby some capability state undergoes transformation to a new state, e.g., from not learned to learned. One might do this to investigate the effect of alternative instructional strategies concerned with increasing the probability of the intended transformation. This can be illustrated using a simple matrix where q is the probability that a student's specified capability exists already, $1 - q$ is the probability that it does not, t is the probability that a transition will occur from the unlearned to the learned state following instruction, and f is the probability that the capability — once demonstrated — will be forgotten over the same time interval (see Figure 1 on next page).

If a person's capability is in state I, it is not known or demonstrable, but when instructional communications are presented, the transition matrix I describes the possible change in state during the designated time period. Rows of the matrix represent the initial state and columns represent its state at the end of the time interval. Although this is a crude model which does not portray the richness of human learning, similar models have proved useful explanatory or predictive devices. And more complicated models are amenable to Markov analysis.

Individual rates of progress through instructional systems can be predicted by treating the sequence of instructional operations as a Markov chain process. Thus, in addition to

Figure 1.
Transition Matrix for Learning/Forgetting.

		Probable State at Time K + 1	
		Learned	Not Learned
Probable State at Time K	Not Learned $p(\bar{L}) = 1 - q$	t	1 - t
	Learned $p(L) = q$	q - f	f

$$\text{or } I = \begin{array}{c} \\ \bar{L} \\ L \end{array} \begin{array}{c} \begin{array}{cc} L & \bar{L} \end{array} \\ \begin{bmatrix} t & 1 - t \\ q - f & f \end{bmatrix} \end{array}$$

theoretical interpretations of learning and instruction, it is possible to predict the number of students at various places or stages in a continuous individualized education system, the number completing their studies and those who will drop out. Similarly, suppose that a person can be found in any of several courses or learning centres; that students may remain or switch allegiance from one centre to another (due to resources, policies or advertising); and, finally, that a representative sample of students yields data on the probability that a person will remain with the centre initially used. Preparing a matrix of transition probabilities enables one to forecast the number of students in each centre in the future or to analyze the effects of changing system procedures. By knowing what to expect in the future the educational planner is in a position to do something to avoid undesirable outcomes. Providing relevant information is an important aspect of educational research where the potential contribution of system analysis is great.

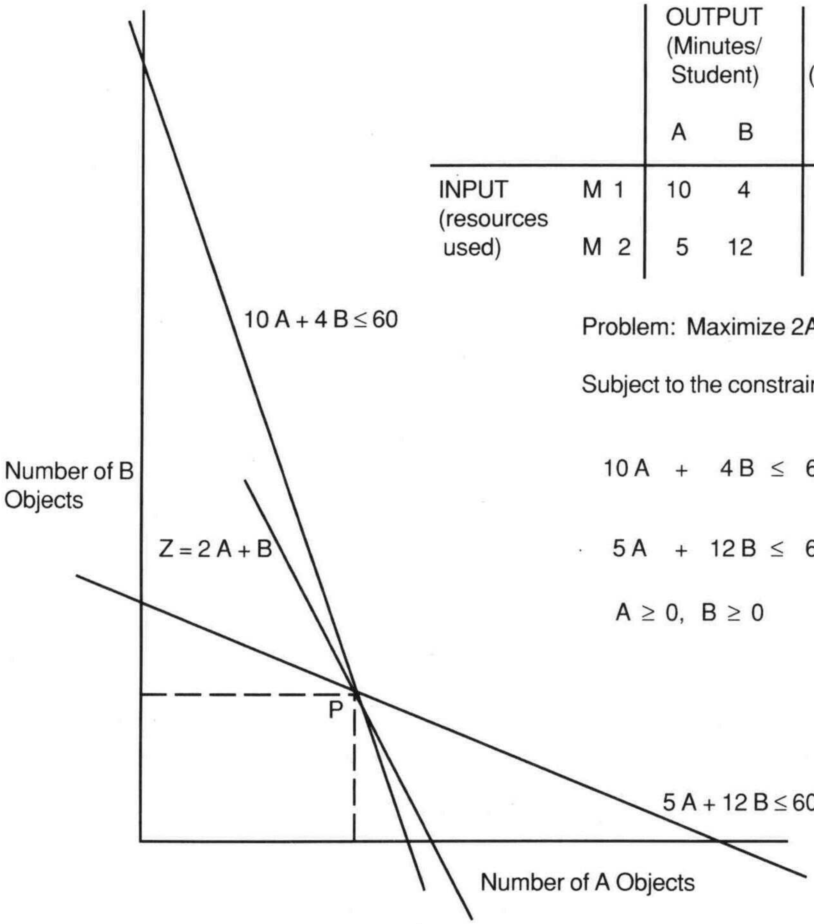
LINEAR PROGRAMMING

Linear programming (LP) is a mathematical tool for allocating scarce resources to competing demands for them. It helps one to find the best *value* for the total outcome of one's decision while simultaneously satisfying several requirements imposed by the situation. Thus one might allocate production facilities to alternative educational materials or allocate personnel to tasks so as to maximize effectiveness of the system. Similarly, given a set of educational objectives and alternative systems or ways in which students might prepare to meet them, it is possible to formulate an idealized way to assign students to learning activities in order to maximize learning (subject to available facilities and learning rates). The measure of effectiveness to be maximized or minimized could be cost, profit (if you market an instructional product or service), research grants, or any quantifiable measure of *educational* effectiveness. The statement that denotes the objective as a function of controllable and uncontrollable variables is termed the objective function.

Linear programming's usefulness reflects its ability to help economize. The objective function assumes proportionality (e.g., a production centre produces twice as much in two time units as in one) which may not hold in practice. Although many feasible solutions can exist for a LP problem, the aim of LP is to find that unique solution that satisfied the constraints and maximizes the value of the solution to the decision taker.

There are essentially three ways to go about linear programming: graphically; analytically; or with a standard computer programme. For a simple problem a graphic solution is easy. Suppose you must prepare modules for a learning centre that has a limited capacity for media 1 and 2. Course objectives fall into two broad categories, A (e.g., evaluation and synthesis) and B (memorization). Research has shown that, in a given time, media 1 enables 6 students to achieve an A or 15 to achieve a B objective while media 2 helps 12 to achieve an A or 5 a B. What is the optimal assignment of objectives and media to maximize the value of this system, given that class A is considered to be twice as important as B? A graphic solution is illustrated in Figure 2. (For more complex problems, requiring more than two dimensions, use a computer.)

Figure 2.
Summary of Solution to Linear Programming Problem.



		OUTPUT (Minutes/ Student) A	B	TOTAL TIME (Minutes)
INPUT (resources used)	M 1	10	4	60
	M 2	5	12	60

Problem: Maximize 2A + B

Subject to the constraints:

$$10A + 4B \leq 60$$

$$5A + 12B \leq 60$$

$$A \geq 0, \; B \geq 0$$

Can LP provide a useful theoretical model or is it limited to economizing decisions of practical import? If we assume the degree of learning to be a linear function of the time spent learning, it is possible to formulate a LP model that portrays the appropriation of each of many different concepts as a result of participating in different categories of educational activity that are subject to restrictions (e.g., the amount of time or human and material resources available is limited). Such a model also assumes we can assign, for each student, the relative educational value of each activity. Having done so, however crudely, it should be possible to investigate effects of different learning strategies — including undisciplined haphazard choice — and to compare them with an optimal strategy calculated to the most valuable utilization of time and other resources available. Such an approach is limited however to a single decision problem.

DYNAMIC PROGRAMMING

Some problems must be broken down into a series of smaller problems (decomposition) and the solution of the original problem is synthesized form the solution to the subproblems (composition). Dynamic programming is such a multi-stage problem solving approach. It solves for a stochastic series of sequential decisions with the outcome of each depending on the previous decision in the series. It is essentially an extension of the LP concept (which assumes a static system with one transition to a new state) to many choices dealing with uncertainty. The *decisions* included in the structure of a DP problem are opportunities to change the values of state variables in a probabilistic manner; each decision is to change the state and maximize the value of the subsequent outcome.

Teaching is essentially an adaptive multi-stage decision process so DP may be a useful analytic tool for the researcher. Since the instructional designer often must apportion the kinds and amounts of adaptation requirements between the instructional system and the student, DP is a useful concept to consider; the paucity of applications makes this an area ripe for research.

SIMULATION

An educational system or decision problem can often be investigated by recreating the effects on the system of relevant inputs through time. A simulation is a procedural model which expresses a dynamic relationship between variables in precise terms (e.g., in the form of a flow chart, set of decision tables or algorithms). By carrying out the sequence of operations on variables and parameters of the model with assigned values we can predict what might happen in the real system including long term effects of decisions. Thus simulation involves features of both classical experimentation and formal analysis in a way that provides great flexibility for educational technology. Usually a simulation is processed on a computer where one can rapidly test hypotheses concerning theoretical questions and practical problems. Simulation models, e.g., of different queueing systems and decision processes, can be investigated using fairly standard procedures. Simulation models are possible not simply for processes or institutions but also for policy decisions. We could even produce a model of the nation of global society to present to mankind the probable effects of present and proposed activities, and to generate and describe alternative courses of action. This might bring into existence new arrangements to foster lifelong education.

Some simulations are useful not for studying the system but for investigating the decision processes of educational managers whose normal behaviour in interplay with the system is difficult to"analyze. Thus a computer simulation of a classroom with 30 students can be used to study instructional planning by teacher trainees or to compare such decisions with those of experienced teachers (Mitchell, 1973). Operational gaming denotes simulations of this sort. Games have pedagogical uses too since they can stimulate both understanding and interest in participants.

CONCLUSION

An imbalance of judgement seems inevitable between educational researchers who focus mainly on statistical techniques and related experimental design principles and those who struggle with practical problems of operating systems. This is complicated by the inability of one person to be expert in all the disciplinary approaches inherent in education. Systems thinking can untie these opposing tensions by providing a common perspective on problems of communication and control (cybernetics), the rigour of scientific and technological research, and the scientific models of operational research *(cf.* Appendix; Ackoff, 1961). Nonetheless we must beware lest we yield, unwittingly, to societal pressures to measure educational activities and human dignity largely in terms of utility. The means-ends language of contemporary techniques distracts us from a vision of man as a temporal being in dynamic equilibrium with the rest of nature. The professional world view and aims of the educational technology researcher/practitioner surely must transcend technocratic distortions if optimal education is to be achieved.

In this paper I have introduced several models suitable for operational research in Education. (A list of suggested readings may be obtained from the author.) Models of this sort are intended not to replace but to supplement traditional educational research procedures. Their usefulness is paramount in but not limited to applied educational research. Improvements in educational technology theory and practice can be expected as educational researchers and decision takers develop competence in operational research.

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APPENDIX

A MODEL EDUCATIONAL SYSTEM ANALYSIS CURRICULUM

Contemporary research and progress indicate that the mainstream of technological thought has been quantitative. Far from providing a restrictive scope, a good grounding in system analysis and operational research techniques should expand one's capacity of comprehension, regardless of his special interests in selected aspects of educational technology. It can truly prepare him to be a generalist.

As an educational programme, the detail with which a curriculum may be specified varies from a terse, molar level (e.g., to develop competence in system analysis) to the extremely refined level of detailed behavioural objectives. In this model curriculum the following intended learning outcomes were established as the first level of resolution. In the Educational Systems Analysis courses offered at Concordia University each of these is elaborated in considerable detail. (Time constraints permit only a cursory treatment of some.)

The student is expected to develop capability in:

1. methods of system description and systems modeling using block flow diagrams and flow graph theory;
2. scientific and technological research methodology;
3. understanding, formulating and using probability theory;
4. evaluating parameters of a theoretical model from available data by statistical inference;
5. understanding, setting up and solving problems of rational decisions using the theory of games;
6. understanding, formulating and using matrix methods to analyze system problems;
7. understanding, formulating and using a Markovian Decision Model;
8. setting up and solving the optimal assignment problem;
9. setting up and solving linear programming problems;
10. formulating and solving problems involving curvilinear or non-linear

programming;

11. setting up and solving dynamic programming problems;
12. analyzing, setting up and solving queueing (waiting line) problems;
13. measurement and evaluating of educational systems;
14. analyzing and controlling costs of educational technology projects and proposals;
15. establishing policies for decoupling systems through inventory control models;
16. describing and using management planning models;
17. educational systems management;
18. computer programming; and
19. constructing, using and interpreting simulation models.
20. The student will begin to develop a cybernetic worldview in which static systems, dynamic systems, purposeful or goal-seeking systems, self-organizing and conscious systems evolve through an exceedingly complex series of mutually adaptive equilibrium responses.

Developing Faculty to Use Videoconferencing to Deliver University Credit Courses Over Cable and Satellite

Diana R. Carl

Abstract: Heinich (1984, 1985) expressed disappointment in the lack of acceptance of technologies into the traditional classroom by teachers. This appears to be a phenomenon across all levels of educational institutions including the university. An important step in this integration is the development of faculty skills in the use of these technologies and the provision of a framework usable in making decisions about the use of specific technologies. This paper documents a paradigm used to develop faculty in the use of one specific technology - videoconferencing.

As higher education invests in and develops newer technologies, faculty face the need to gain skills in the effective use of these technologies for teaching. The ability to use these new tools is not necessarily present nor is it self-evident. One only need to reflect on the process involved in learning to use a pen, a fairly simple technology by today's standards, to realize that a grasp of the alphabet, words, syntax, and context was not obtained overnight. The same can be said of learning to teach using the technologies available today. Heinich (1984, 1985) has lamented the lack of acceptance of instructional technologies by teachers in educational institutions.

Universities have been considered slow in the adoption of new technologies for higher education (Ham, 1983). But Habermas (1973) points out that this slowness is indicative of a deliberate, reflective process used in assessing the technology for their own purposes and for the purposes of the communities served.

> An institution of higher learning which is enlightened with respect to the critique of science, and also politically capable of action, could constitute itself as an advocate to urge that among the alternatives of priority for scientific and technological progress, the decision is not made automatically according to the "natural laws" imposed by the military-industrial viewpoint, but is decided, on the basis of a general discursive formation of will, only after weighing politically the practical consequences. (Habermas, 1973, p. 6)

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The formation of will described by Habermas takes time and deliberation before the decision to endorse a technology is made. Roueche and Snow (1978) and McCombs (1985) state that instructional technologies can hinder the teaching/learning process unless teachers have skills to use them, well. In attempting to integrate technologies into the teaching by faculty, there is a need to provide the opportunity for discourse to assess the technology, and secondly, to develop in faculty knowledge and skills which will enable them to make informed decisions about the character of their presentations using these technologies.

The Videoconferencing System

The combination of a live television signal being sent to a series of locations coupled with the return verbal exchange over telephone lines is known as one-way videoconferencing. That is, the originating site has cameras to transmit the visuals and sound from the site. Other sites can participate separately or collectively using telephones and teleconferencing equipment to communicate orally with the originating site. Mount Saint Vincent University selected videoconferencing for distance education in 1981. The system, known as Distance University Education via Television (DUET), uses a live classroom presentation including on-campus students. The presentation is transmitted to distant students studying at home or in receiving centres at work. Students participate in the class by means of a telephone connected to a teleconferencing bridge enabling them to talk with the professor, students in the originating classroom itself, and students at other locations. DUET students view the course using satellite and cable television services. They complete the same requirements as do on-campus students and work on the same schedules as on-campus classes and activities.

Videoconferencing was selected because it enabled the university to reach a distant student population without investing in a separate course structure or heavily in technology. As the class *piggybacks* on the existing courses scheduled to be offered on campus, videoconferencing is an uncomplicated means to maintain equivalency between the standards for course completion on campus and at a distance.

The administration wanted the university to become mobilized to engage in distance education as easily as it accomplished on-campus teaching. As individual professors are responsible for the teaching which occurs in the classroom, the university wanted this same delineation of responsibility and autonomy to extend to the practice of distance education. Since distance education normally calls for the employment of technologies and methods alien to faculty, faculty needed to be prepared to use these technologies routinely in their distance teaching, to be able to make informed decisions regarding use, and to ultimately use these technologies in individually creative ways in their teaching.

Although there has been much discussion about the suitability of face-to-face courses for distance education, Mount Saint Vincent University used the face-to-face course as the basis for developing the videoconferenced version. Most distance education is developed using a course team approach (Holmberg, 1985), which is problematic for the structure of the university (Carl, 1985). There have been criticisms of the teaching ability of faculty and extension of this to the conclusion that university faculty should not be exposed to distant students. There are, however, indicators that this is an overstatement of the situation. While university faculty generally are unfamiliar with the principles found in course design (Shrock, 1985), my observations indicate at least a rudimentary sensitivity to student which is reflected in the course structures. If the faculty member's course has the approval of the academic department and Senate and has a significant history of being taught and revised, the course and faculty member are considered candidates for videoconferencing development.

The Goals of Faculty Development in DUET

The major goal of the workshop is the introduction of faculty to videoconferencing as well as further constructive discussion of this technology among the faculty themselves. An analysis of the beliefs and attitudes of the Mount Saint Vincent University faculty population indicated a lack of understanding regarding the distinction between commercial television, educational television, and videoconferencing. In making decisions regarding course development for videoconferencing, I noted that faculty tended to base decisions on a need to reach a mass audience rather than to attain educational outcomes. Finally, the passive medium of television had to be distinguished from the participative medium of videoconferencing. Specific objectives were generated for the workshop:

1) faculty would be able to distinguish between commercial television and educational television, and between videotaped formats and videoconferencing;
2) they would point out several ways in which teaching over a videoconference system is different from, and similar to, face-to-face teaching;
3) they would discuss specific issues related to developing their own courses for DUET, citing examples from the workshop; and
4) they would be able to discuss the effect of learning by means of a videoconference system.

The primary topics of the workshop were derived from a task analysis:

1) the distinct characteristics of videoconferencing;
2) the technical components of videoconferencing;
3) the elements of face-to-face instruction;
4) the distinctions between face-to-face delivery and videoconferencing;
5) techniques for effective instruction in videoconferencing; and
6) techniques for effective class management in videoconferencing.

Educational Videoconferencing Distinguished from Educational Television

As a medium for expression and as a means for the delivery of instruction, television is still regarded with much suspicion in academia - although I see evidence that this is gradually changing. Faculty I have encountered have described television as a passive medium and one used primarily for (mindless) entertainment. One need only look at the products of PBS, TVOntario, or of the Open University to recognize that most of the programmes are passive, noninteractive videotape presentations. These reflect many of the values of commercial television, using techniques to attract and hold a mass audience. Preproduced graphics, semiscripted or fullyscripted formats, elaborate sets and lighting arrangements are readily viewed examples of this influence on educational television. Academics who view commercial and educational television have developed assumptions about how the medium should be used based on their own primary experiences with television as a mass medium and with little attention to educational outcomes and processes. Some studies describing the attributes of various technologies reinforce these assumptions but, as Solomon (1979) points out, treating technologies as "invariant, discrete entities" (p. 7) is to ignore the number of possible ways in which the technology can interact with learners and content and to limit the perception of what can be accomplished with the technology.

To understand this mind set, one might compare presentations on television to presentations found in books. If one only read technical reports, then one would tend to expect all books to have the same type of format and style. The concept of a different style and format for modern fiction or for Shakespearean literature would be foreign to that reader. In much the same way there has been a tendency in higher education to use formats and styles of commercial television as opposed to selecting style and format based on educational intents (Blake, 1984; Carl, 1984).

As well, faculty often mistakenly identify videoconferencing with the passive medium of television. In videoconferencing the television signal is sent live as it occurs to the learner. Learners can interact with the live presentation via the telephone. The comments of distant learners are intended to influence the presentation and format, which becomes responsive to the learner both visually and through the dialogue which occurs. Thus, it is not so much the intention of educational videoconferencing to attract and hold a passive mass audience as it is to stimulate participation in the learning experience. The format is by definition immediately flexible to the needs of distant students, enabling an immediate change in strategy as distant learner participation indicates a change is in order.

In summary, the distinction between the elements of commercial television and educational television is important to faculty development in videoconferencing in that they be able to recognize the relationship between selection of elements in the program and the desired outcome (i.e., to attract a share of the mass audience or to educate). Secondly, the distinction between videotaped and videoconferenced formats is important so that faculty recognize the potential synergistic relationships which can be accommodated using videoconferencing.

Face-to-Face Distinguished from Distance Instruction

University systems have been structured to support face-to-face instruction (Heinich, 1984). Faculty are most familiar with face-to-face teaching. They have been reluctant to adopt technologies and strategies which separate them from their students and are skeptical about incorporating advanced technologies into teaching. In a study of the use of another advanced technology in education, computer-assisted instruction, Sprecher and Chambers (1980) state that one concern faculty have is that the use of these technologies will hinder the social development of the student and the social process they perceive as important for learning to be internalized. Faculty view themselves as stimulating the social environment of the student so that learning comes not only from the professor and printed resources, but also from thought-provoking interaction with peers.

Unfamiliar technologies themselves threaten faculty (as they do many people). The faculty member who does not know how to use an overhead projector or who fumbles loading a film projector, feels a loss of control over the learning environment and an inability to effectively direct the learning experiences of his or her students. The problem is compounded when the students are not in view of the professor. There is no immediate visual feedback to the professor as to how the students are responding to the instruction or to the technology employed. The instruction and the interaction, then, are altered by the technology through which it is filtered.

Few researchers have treated the issue of combining the distance and face-to-face presentation in a single session. Holmberg (1985) discusses combination, but it is unclear whether he is referring to sessions in which the instructor is teaching both on-campus and distant students or to the use of distance procedures combined with some oral classes with distant students. Haughey (1983) and Catchpole (1985) describe the delivery of videoconferenced courses exclusively for distant students. In many studies presentations via distance technologies have been compared both favorably and unfavorably with face-to-face presentations.

A review of the literature on educational technology, distance education, and teaching improvement appears to indicate that the face-to-face presentation normally used in universities has been the target of much criticism but has received little definition or analysis. Some (e.g., Harrington, 1977; Sweeney & Reigeluth, 1984) point out that there is evidence supporting the validity of traditional methods, while proponents of distance education and educational technology (e.g., Shaw & Taylor, 1984; Jevons, 1984) argue the opposing point of view. In assessing the arguments of distance educators, it is questionable whether they have really identified the problem in working with university faculty. This may be a case of a solution in search of a problem. Faculty who have taught a course at least once have received feedback from their students and have used this feedback to make changes to the course. Although the course may have not been designed according to respected principles of instructional design, a measure of instructional design has occurred for the on-campus course. It appears questionable, then, to assume that the face-to-face presentation is an unsuitable basis for the development of distance education. The decision to adapt an existing on-campus course to a technology is multi-variate and should not necessarily rely on ways in which the technology has been used in the past.

Faculty, then, require skills and knowledge which will enable them to understand how the technology filters the instruction and the effects it has on interaction if they are to overcome anxieties and are to effectively use the technology. Thus, a second objective of faculty development in videoconferencing is enabling faculty to examine how a videoconference to distant students alters the message (i.e., the course designed for on-campus students), and to effectively control and manage the learning process for both on-campus and distant students.

The Paradigm for Analysis of Teaching for Transfer to a Technology

The literature on distance education distinguishes between dedicated distance education institutions (those which offer courses exclusively to distant students and thus have been specifically designed for distance delivery) and bimodal institutions which offer courses both on campus and at a distance (Jevons, 1984; Holmberg, 1985; Stubbs, Lumsden, & Knapper, 1985). In bimodal institutions, distance sections of a course are normally segregated from on-campus sections and undergo a separate development process for exclusive delivery to distant students. Karpiak (1985), for example, demonstrated this segregation in a survey of distance languagecourses in Canada. DUET is peculiar in that the presentation is at once a face-to-face and distance presentation and must result in effective learning for both a face-to-face group and a distant group. Therefore, the course design has to be structured to yield an effective face-to-face experience while also yielding an effective distance experience filtered through the technology.

Redevelopment of existing courses has been an area of contention in the literature. Heinich (1984, 1985), Shrock (1985), Shaw and Taylor (1984), Romiszowski (1981), Harrington (1977), and Jevons (1984) have expressed frustration at the lack of cooperation by educationists in using course development techniques and educational technologies in their work. It has been an easier route to develop separate administrative and course structures for using educational technologies and delivering distance education (Carl, 1985). Little discussion appears to have taken place regarding the adaptation of existing administrative and course structures to educational technology. Those who have treated it (Mizell, 1978; Clark & Angert. 1981; Shrock, 1985: Shaw & Taylor, 1984; and Moses, 1985) appear to consider adaptation of courses to be an issue of faculty development and have made few inroads in changing the traditional academic structure.

It is notable that there were few models or case descriptions found in the literature which could serve as a guide for systematic analysis directed to the adaptation of a course to educational technology. Barrow and Meacham (1983) adopted the "science of muddling through" described by Lindblom. Stubbs, Lumsden, and Knapper (1985) have also referred to the use of muddling through at the University of Waterloo. Holloway (1984) describes a model for adaptation in very general terms, appearing to suggest that technologies be adapted to existing situations and structures. He cites grounded theory (theory based in demonstrated events and facts) as a basis for adaptation. In developing new technologies for education, however, relying on a history of observable data may be impossible: a systematic history may not exist for a particular technology. In addition, the grounding of past experiences merits questioning to determine how valid they are for generalization to the present course.

Vedros and Foster (1981) presented a model for trouble-shooting defects in instructional programs which might be considered a basis for adaptation. The model serves as a good general basis for examining a macro-system of education but provides no details for an analysis of the individual interactions among teacher, subject matter, and students that link presentation to intended outcomes. What appears lacking is a model for systematically examining the existing course and prescribing a rational adaptation to distance education and to the technology employed.

In adapting a course to videoconferencing, it is important to retain those elements of the course design which appeared effective for the on-campus mode while changing those which were not effective or which would not be adequately experienced at a distance through the available technologies. There was a need for a structure by which the existing on-campus instruction could be analyzed for videoconference delivery.

The purpose of this analysis is to ensure the existing course has a sound basis from which to work and to later determine the potential effects of these elements as they were massaged by the technology. The structure selected for this purpose was the mathetics model (Gilbert, 1962) which could be used to analyze the elements of the face-to-face instruction and their effects on the student population. Gilbert's work, influenced by Skinner, is the application of a behavioral approach to instruction. Gilbert has influenced the work of other instructional designers (Romiszowski, 1981; Gagne, 1971; Cropper, 1983; Merrill, 1971). While other analytic models have evolved from Gilbert's model, Gilbert (1974) used mathetics as a basis for discrepancy analysis which can be used to determine where problems lie in the performance of a student. Using Gilbert's model, one first describes the ideal performance of a student and then uses the model to determine where the discrepancies lie between the model and actual performance.

Mathetics is defined as "the systematic application of reinforcement theory to the analysis and reconstruction of those complex behavioral repertories usually known as *subject-matter mastery."* (Gilbert, 1962, p. 8). Romiszowski (1981) summarized mathetics as the combination of behavioral chains, discriminations, and generalizations which in combination form a level of mastery. The simplest unit upon which mathetics builds is as follows:

S—>R. Sc

where S is the stimulus (or presentation to the student), R is the response the student gives to the stimulus, and Sc is the reintbrcer which becomes the stimulus for the next response thus setting the stage for chains, discriminations, and generalizations. This unit is important to this paper in that it is used as the basis for the discrepancy analysis model used in analyzing the existing on-campus instruction prior to preparing it for videoconferencing.

Romiszowski (1981) states that "Gilbert suggests the preparation of a behavioral *prescription, a* map of all the separate behaviours that make up mastery of the task being analyzed" (page 89). This map defines the desired outcome of the instruction and the systematic relationship of all performance elements to that outcome. Using the scheme as an analytic model for existing university instruction, one begins by constructing a model of the ideal performance of a student who would be considered to have successfully completed a course. During the process it is not uncommon that the model of ideal performance is altered. By *backward-chaining,* one can determine the relationship of various sub-behaviours, presentations, and assignments to the ideal performance, mapping the links and gaps in the existing instruction. Using this technique it is easier to discuss the elements of the course with the professor and to determine the weaknesses, which can then be addressed. The analysis tells the instructional designer and professor where the gaps appear but does not provide a guide to remedy the instruction.

The discrepancy analysis (Gilbert, 1974) identifies these shortcomings. Using a discrepancy analysis, it is possible not only to find where the gaps in the instruction occur but to locate where in the performance chain the problem is occurring. Gilbert named three possible *areas of causation* for non-performance:

1) *The environment:* the environment is preventing clear perception of S, interferes with R, or presents a competing Sc which is stronger than the Sc associated with a model performance.

2) *The student's repertory of behaviour:* the student has not learned to perceive the S, lacks the knowledge of how to respond, or has no knowledge of the Sc.

3) *The students themselves:* the students have difficulty perceiving the S, have physical difficulties which prevent R, or do not see the Sc as important.

Figure 1 (see next page) shows the matrix of performance analysis.

In using this model to analyze the existing on-campus instruction, the instructional designer gains a clearer understanding of the intentions of the course and how the elements combine to yield the desired learning. The intentions, presentations, interactions, assignments, and tests are categorized in observable terms which the instructional designer and professor can use in determining whether learning is taking place. In total, through this process the existing course is:

Figure 1.
Performance Analysis.

AGENT	S	R	Sc
Environment	Inputs are not clear	Interference prevents the response	Consequences of behaviour are out of balance
Student's Repertory of Behaviour	Cannot generalize or discriminate the stimuli	Lacks the skill to make the response	Student gets no confirmation of her/his behaviour
Students	Unable to perceive the stimuli	Unable to make the response	Doesn't care

1) analyzed for soundness in its present version;
2) translated into terms which are more discernable to both the instructional designer and the professor;
3) mapped to determine the relationship of the various stimuli, responses, and reinforcers to the overall outcomes and to uncover gaps, ineffective stimuli, irrelevant responses, or ineffective reinforcers; and
4) prepared for adaptation to distance delivery using videoconferencing.

As a side note, it is important to realize that professors allowed this analysis of the on-campus instruction to proceed because the course was to be adapted to distance education. I have noted that when I have tried to use this approach for analyzing problems in courses not destined for DUET, faculty appear reluctant to engage in the process.

The structure of the on-campus course having been dealt with, the next phase of the analysis is concerned with determining the effect the distance technologies have on the existing instruction and to plan so that the same course can be effectively delivered at a distance. As the medium massages the message (McLuhan & Fiore, 1967), the technology massages the elements of the course: the S, R, and Sc. The elements of the presentation (S) are altered by their presentation on the television screen. The discussions, class exercises, and assignments (R) are altered by the presence of a different technology which must be used in making the response. Using the technology to perceive S and to respond will present different consequences (Sc) to the student than those found in the face-to-face situation.

A second layer is added to the discrepancy analysis to examine the effects of the technology on S, R. Sc. The intent of this phase is threefold:

1) to determine the effects of the technology on each element;
2) to arrive at a prescription to ensure the distant student has
   a) adequate perception and understanding of S as it is presented via the technology, and
   b) opportunity for and comfort with R as they make the response via the technology ; and
3) to identify and use valued and recognized reinforcers to using the technology for instruction.

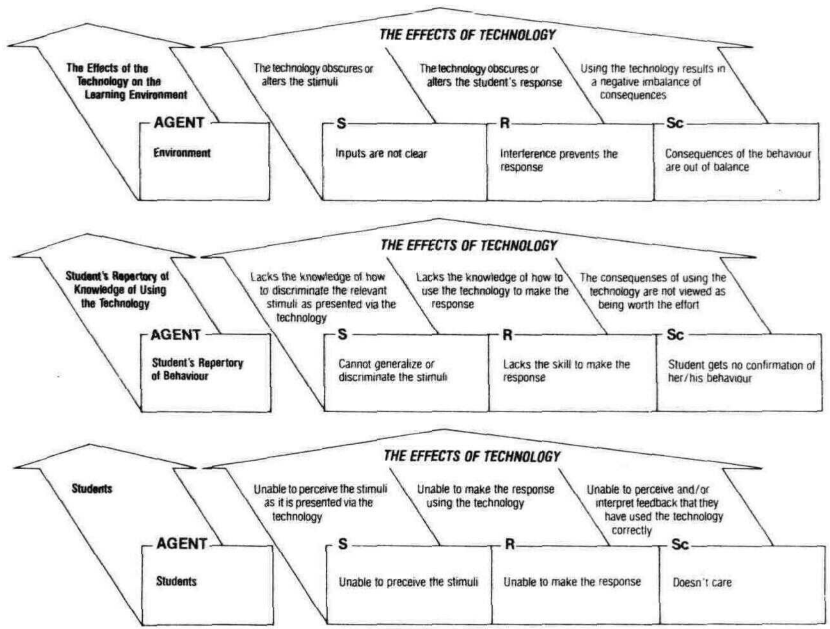
Each cell of the discrepancy analysis is examined to determine the effect of the technology on that cell. For example, in the cells at the first level, environment, the use of the television format could distort or inhibit the perception of some S, such as a diagram drawn on a chalk board. The telephone technology might have distortion on the line which interferes with responding. Noise on the line might result in an imbalance of consequences (Sc) in which it is more rewarding for the student not to respond. At the second level, repertory of behaviour, the student may not know how to perceive S as it is presented through the technology, may not know how to respond (R) using the technology, or is unaware of the consequences (Sc) of responding via the technology. At the third level, the student may be physically unable to perceive S using the technology, is physically unable to respond using the technology, or does not perceive responding as being worth the consequences (Sc). By examining each cell, the estimated and actual effects of the technology can be diagnosed so that a prescription can be written which will promote an optimum experience using distance technologies. Figure 2 (see next page) demonstrates this augmented model of discrepancy analysis.

In addition to the analysis of the face-to-face instructional experience, the dynamics of class management are explored relative to the experience the professor wishes to provide. In each faculty-student contact, there is a style of management, asserted by the faculty, to which the students respond. The situational leadership paradigm of Hersey and Blanchard (1982) is directly transferable to education. The type of style, according to Hersey and Blanchard, should reflect the student's familiarity with the instructional task and the *willingness* of the student to engage in the activity. In practice, the use of situational leadership means that, depending on the student's knowledge of the subject and attitude, the professor should adopt an appropriate way of interacting with that student. Students enrolled in an entry level course may require a more highly directive leadership, while those enrolled in a senior seminar will require more support but less direction. Figure 3 (see next page) represents this relationship.

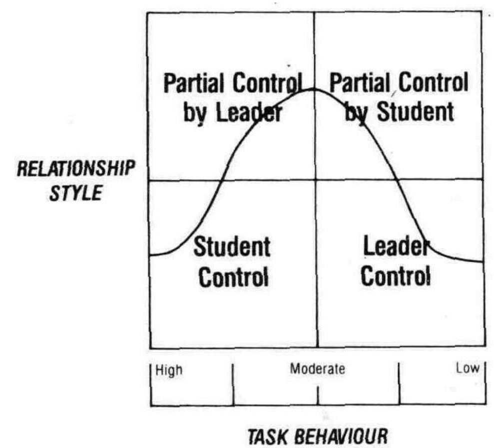
The concept of situational leadership calls into question the concept of the adult as a self-directed learner. Initially in the learning situation, people will require increased direction until they are more assured in their abilities to learn. Fales and Burge (1984) describe, for example, the initial confusion and insecurity of adult students enrolled in a teleconferenced course until they received well-defined instructions. The need for external direction and reassurance diminished as students became *self-directed.* Lam (1985) linked the instructional approach used in both higher education and in community colleges with the cognitive maturity of the student, pointing out that adult learners lacking experience in formal education desire a more structured approach while their more sophisticated cohorts prefer less instructor-dominated experiences. This would seem to indicate a need for the class management style of the professor to match the skill level of the student as opposed to implementing self-directed approaches for all adult learners. The management style would change as the students become more familiar with the subject matter and the task.

As the choice of style relates to familiarity with content, familiarity with the method of learning employed is also a factor in selecting a leadership style. Students who are unfamiliar with given learning strategies or technologies may fail not because of a lack of understanding of the subject, but rather because they do not know how to learn using the strategy or technology employed.

Figure 2.
*Expanded Performance Analysis: The Effects of Technology nn the S-R*Sr Chain.*



Figures.
Situational Leadership Applied to Education.



> Situational Leadership may provide some insights into problems that have developed in the innovative self-pace learning curricula that have sprung up across the country at many educational levels...These programs have been developed in an attempt to individualize instruction and are premised on maximum freedom for the student...The intention now is for the students to initiate structure for themselves. The teacher becomes involved only at thestudent's request. (Hersey and Blanchard, 1982, p. 166)

Although many people know how to use the telephone and television, they have not used these media for learning. In using these technologies for learning, they employ behaviors which work well for socializing or being entertained, but which interfere with the student's ability to learn effectively from using the technology. Therefore, in directing the learning of students new to videoconferencing, professors should be aware that more direction is needed to enable the students to use the technology for learning until such time as the students demonstrate a facility in its use for education and a willingness to participate using the technology.

Faculty development in DUET, then, concentrates on creating an awareness in professors of their class management style and its impact with regard to teaching the subject. Professors are also introduced to the interaction of the technology with the subject so that they recognize the effect of the technology on their students and can provide an appropriate style to ensure an effective learning experience.

In order to provide an effective learning experience using the distance technology, then, the professor needs to be aware of:

1) the level of familiarity the student has with the content; and
2) the level of familiarity the student has with using the technology.

The management style used will vary depending on both these variables. A student, for example, who is quite familiar with the subject area but not familiar with using the videoconference system for learning will need a high degree of supportive behaviour from the professor in learning the subject but will need a high degree of direction in learning to use the technology.

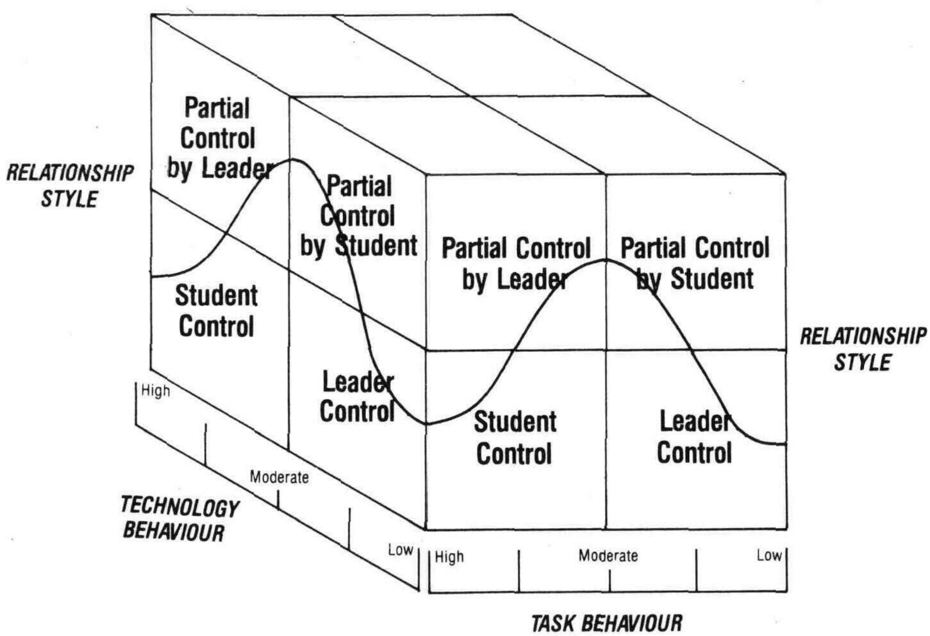
To assess the level of the student for each task, a third dimension is added to the Hersey and Blanchard model to aid in the decision about the appropriate class management style. Figure 4 illustrates this added dimension and the types of management style which might be employed for the two tasks.

The style selected is dependent on two tasks the student is to accomplish: learning the subject matter and learning with the technology. This calls for the professor being aware of these two tasks and exercising one type of style in teaching the subject but possibly a second style to facilitate the learning experience using the technology.

The Strategy in Action

The models are presented to faculty during a hands-on workshop held each semester in the DUET facility of Mount Saint Vincent University. During these workshops opportunity for hands-on experience in presenting a lesson through videoconferencing is provided, as well as the chance to experience the lesson as a distant student would. It has been useful to

Figure 4.
Expanded Situational Leadership Applied to Educational Technologies.



promote open discussion on both the positive and negative observations of videoconferencing as it is presented in the workshop. Botman and Gregor (1984) and Moses (1985) have noted that in higher education encouraging faculty to engage in individual consultations, to reflect on the applications of teaching improvement programmes and to engage in peer discussions regarding issues about the concepts presented, is an important part of such programmes. Faculty have responded positively to unobstructed inquiry into the relative merits of videoconferencing. This, in turn, has been beneficial in promoting examination of pedagogy in the university setting, examining the uses of other technologies in higher education, and in establishing a higher degree of comfort with videoconferencing and inviting further exploration.

For those professors electing to develop entire courses over DUET, the process which began with the workshop takes on more breadth. Strategies for long-term support to distant students throughout the course are developed. These include access to library resources and creating channels through which non-verbal assignments and interactions can be effectively used by distant students to communicate with the professor. For example, in planning the Introductory Accounting course, it was discovered that the standard accounting sheet could not be viewed clearly enough for learning over television screens. Extensive redesign of the visuals for the course was undertaken to ensure that distant students could visually process the accounting procedure from the television screen. It also became evident during the process of analysis that the capability of DUET's videoconferencing facility offered more opportunity for visualization than was possible in the normal classroom. The decision was made to use the video to enlarge the experience of the in-class group as well as that of distant students.

Developmental analyses of courses do not always result in a decision to proceed with a course over DUET. In one course, the need for visual confirmation of the skill level of distant students proved difficult with the one-way videoconference system. The decision was made to delay development of the course for DUET until suitable visual feedback mechanisms could be established. In yet another, we realized that the professor was exhibiting non-verbal behaviors which displayed to his students his uneasiness with the technology and which appeared to make distant and in-class students uncomfortable in their learning experience. In another, it soon became evident that the professor would not recognize nor be sensitive to the needs of her distant students. In all these cases, the decision was made not to proceed with the course.

Ultimately, the goal of faculty development for DUET is that faculty will become comfortable enough with the potentials of videoconferencing to experiment with new methods and develop their facility for on-going planning for the technology. For those professors who have taught on DUET at least once, there is informal evidence that this skill is being honed as might be expected. I have noticed that these faculty have begun taking more initiative in developing other courses for DUET, and have employed the concepts and practices formulated in the earlier sessions. They are beginning to experiment with using videoconferencing in individualistic ways for instructional purposes. Some have begun to shoulder more responsibility for organizing their own supports to distant students.

Development opportunities have been offered for eight semesters to groups both inside and outside Mount Saint Vincent University. Workshops have been consistently filled to capacity. Responses to the workshops have been very positive in both verbal and written responses. Some comments have been as follows:

> (I liked) the interaction among all present. A very comfortable experience. The individuality of each person was appreciated and understood by others ...it was a marvelous experience.
>
> ...looking funny on TV is no longer a problem for me.
>
> (I liked) your openness to suggestions.
>
> I realized that such a wide variety of skills and disciplines could be utilized.
>
> There was a chance to try new things in a non-threatening situation.

The primary drawback of the workshop appears to be the time element. Due to time constraints, the workshop is only one day. Obviously, more long-term attention is needed if faculty are to reach a level of creative productivity in using the videoconference system.

Summary

Ham (1983) has suggested that the university as an institution will mold technology to education rather than education to technology. In determining how technologies are put to use by society, then, the university's involvement in assessing and developing technology becomes important. The outputs of the university are that of its individual faculty. As each one has learned to use the pen effectively in research and in education, the challenge for the faculty of tomorrow is to develop their facility in creating academic communications and to personalize the technology to the individual teacher/student relationship.

Faculty development for DUET has been structured to be a rational approach to enable the university to become involved in distance education and educational technologies using existing course and administrative structures. The intent is to prepare faculty to use these technologies effectively in planning their own distance courses.

In this paper the role of videoconferencing and its distinguishing characteristics from other related video technologies were demonstrated and discussed . Decision-making for videoconferencing differs from that employed for non-interactive video formats. Likewise, the intents and structure of educational television differ from those of commercial television.

A model for analysis and preparation of an existing on-campus course for videoconferencing was generated from Gilbert's (1974) discrepancy analysis. The model provides for dissection of the course elements so that the soundness of the existing course can be determined. Discrepancies among wanted outcomes, presentations, and assignments can be identified, clarified, and discussed. The effect of the technology on each element is analyzed and a prescription arrived at to plan for an optimum learning experience at a distance.

The effect of class management styles on the learning and on using technologies for learning was discussed. It was suggested that professors be aware of the skill level of students in two areas: degree of familiarity with the subject matter and degree of familiarity with learning using the specified technology. The style of class management employed will depend on the student's level of skill in learning the subject matter and on the level of skill in using the technology for learning.

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Experiential Learning and the Instructional Design Process

James J. La Follette

Abstract: A descriptive theory of experiential learning, as recently refined by David Kolb, presents a holistic perspective on learning which combines experience, perception, cognition, and behavior. The theory promises to provide the basis for an integrative and prescriptive theory of instructional design.

Aspects of behavioral, cognitive, and affective traditions are reviewed with respect to their contribution to instructional design theory and practice. The structural dimensions underlying experiential learning theory are summarized and one approach to operationalizing instructional design consistent with experiential learning is introduced.

A descriptive theory of experiential learning has been evolving for several decades. As related by David Kolb (1981; 1984) the molar concept of experiential learning is revealed as an intellectual perspective on human learning and development that is at once pragmatic and humanistic. Kolb proposes that experiential learning theory provides a holistic integrative perspective on learning that combines experience, perception, cognition, and behavior. Important contributions to the theory have come from the behavioral, cognitive and affective (humanistic) traditions. It is a major premise of this article that a similar perspective may be extended to operational models of instructional design to provide a holistic integrative approach to designing instructional experiences.

It is the central role of experience in the learning process that differentiates experiential learning theory from rationalist and other cognitive theories of learning and from behavioral learning theories (Kolb, 1984). However, experiential learning theory does not in any sense discount behavioral and cognitive theories. Instead it seeks to accommodate many of their important aspects, along with contributions from affective and humanistic traditions. Figure 1 (see next page) delineates the scope of theoretical positions which experiential learning theory proposes to accommodate.

This article will review the contributions of the behavioral and cognitive traditions to contemporary instructional design practice and explore the role of the teacher in instructional design. Approaches to accommodating individual differences in instruction are reviewed. The

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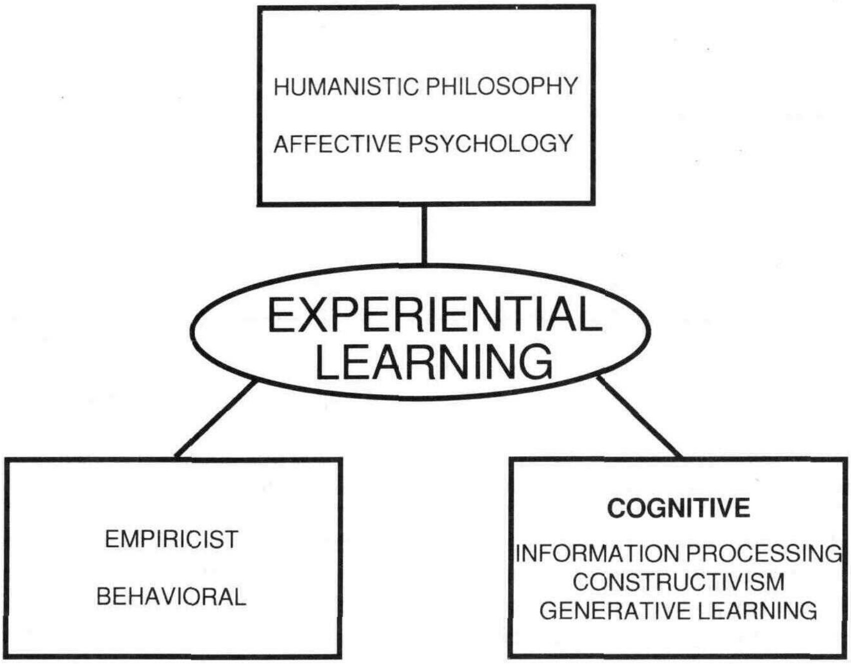
Figure 1. The Range of Theoretical Positions Which Experiential Learning Promises to Accommodate.



potential contribution of experiential learning theory to instructional design theory and practice is summarized. Finally, one approach to instructional design based on experiential learning theory is examined.

SCIENTIFIC KNOWLEDGE VS. HUMANISTIC KNOWLEDGE

Considerable debate within education has revolved around differences in the way knowledge is perceived and dealt with, as well as what knowledge is presented to students and the way it is presented. *Scientific* knowledge is contrasted with *humanistic* knowledge. The former involves truth claims that can be verified publicly, while the latter deals with value systems; phenomena that have ambiguous referents and which tend to defy scientific validation. An emphasis on the acquisition of abstract concepts and factual knowledge often clashes with the goals of humanistic educators, who advocate types of knowing which involve valuing and understanding, the outcomes of which cannot be easily verified (Broudy, 1977). Olson observed that the emphasis on scientific knowledge "has become both a predominant goal of instruction in the schools, as well as the primary means for the achievement of other goals" (1977, p. 87). An examination of the theoretical underpinnings of contemporary perscriptive models of the instructional design process reveals that the descriptive theories upon which they are based have been heavily influenced by the emphasis on scientific knowledge.

THE THEORETICAL BASIS FOR CONTEMPORARY INSTRUCTIONAL DESIGN

Instructional design as a prescriptive science has gradually assumed the status of a *linking science,* connecting the descriptive science of learning with the practical professional activities of teachers and instructional developers (Glaser, 1976; Reigeluth, Bunderson & Merrill, 1978). Prescriptive models of the instructional design process have been derived from the evolving prescriptive science of instructional design.

Behavioral and Systems Theories

Prescriptive models of the instructional design process which have been available to teachers and instructional developers are based mainly on behavioral learning theory and systems approach principles (Briggs, 1970; Davies, 1973; Davis, Alexander & Yelon, 1973; Gagne & Briggs, 1979; Dick & Carey, 1985). Such models stress identification of skills students need to learn (observable outcomes), the instructional events and methodology required, and the collection of data to revise instruction. The self-correcting feature of the design procedures has encouraged planned systematic progress toward understanding, improving, and applying methods of instruction.

Despite their apparent advantages, it has been claimed that models for the design of instruction based on behavioral learning theory and the systems approach have not had a major impact on education, aside from materials development and training applications. As Wildman and Burton (1981) observed: "Systems approaches have seemed too mechanistic and too complex to receive serious consideration by many within the large and diverse population of public school educators" (1981, p. 5). Furthermore, the models tend to characterize instructional events in terms of their manifest or surface features and do not take into account the processes intervening between the stimulus display and the learning (Bovy, 1981). Such models also focus on procedural knowledge, which is bound to context and difficult to transfer (Clark & Voogel, 1985).

Instructional design practice in the behaviorist tradition has often been influenced by *cybernetic* models of learning, which place a great deal of stress on the instructional designer having determined anticipated feedback, sequencing goals and objectives, and controlling the learning process (Fosnot, 1984). While such control may be quite acceptable for many learning tasks where there is general agreement on desired outcomes, it is rejected by advocates of cognitive theories of instruction which identify learners as active individuals modifying (constructing) their cognitive structures through experience.

Cognitive Theories

An orientation based on cognitive learning theory has been considered promising for the complex types of learning that are of primary interest to contemporary educators. A cognitive approach related to learning from instruction involves understanding interactions between the learner's cognitive processes and aptitudes, and the characteristics of instructional treatments. Recent cognitive theory proposes that while in the process of comprehending information, students generate perceptions and meanings for that information based on prior learning (Wittrock, 1974; 1979).

While there is considerable overlap, three cognitive perspectives emerge from recent work on cognitive learning theory, which are capable of providing insight to instructional design practice: information processing; constructivism; and generative learning.

The information processing approach assumes that a number of processing stages occur between a stimulus and a response. Each stage operates on the information available to it, and the output of each processing stage is input for each succeeding stage (Rose, 1980).

Constructivism relates to the building up of individual, prior knowledge structures that enable individuals to construct personal models of reality. Thus, in instruction learners are required to use the material presented to reconstruct or represent their knowledge structure (Jonassen, 1984).

The generative theory of cognitive learning, developed by M. C. Wittrock and his associates, is one of the more elegant manifestations of constructivism which has been proposed. In this theory learning is identified as the transfer of previous learning, but the goal is learning with understanding, defined as long-term memory plus transfer to conceptually related problems. The learner must take an active role in instruction, and even when given the information, the learner must still discover its meaning (Wittrock, 1974; 1977; 1979).

Although the cognitive theories make many suggestions for improving instructional practice and point out shortcomings of existing behaviorally based models, specific applications to cognitive theory in present operational models for instructional design and development are rare. While the instructional design literature is beginning to embrace descriptive models stressing the cognitive view of learning, such views are not generally accepted or employed in various instructional design models (Winn, 1982; Clark, 1984; Fosnot, 1984; Jonassen, 1984).

However, suggestions for possible integration of cognitive learning theory with instructional design models are appearing in the literature. Wildman and Burton (1981) noted that humans tend to cycle through episodes involving (a) simple reception of information within cognitive structures; (b) restructuring or transformation of structures; and (c) the fine tuning of intact and mature structures. The suggestion is that in progressing to a prescriptive model, it is relevant to plan actively for this cycling or sequencing of learning behavior. In this sense the learning curve is seen as a qualitative one, consisting of a series of rising hills as opposed to a straight diagonal line (Fosnot, 1984).

Further progress toward integrating cognitive learning theory into instructional design practice is seen in the elaboration theory of instruction (Reigeluth & Stein, 1983). This approach attempts to accommodate use of the learner's prior experience by presenting different levels with similar instructional content to each previous level, only presented in greater detail or complexity. Thus a systematic review process is incorporated into the instruction.

While cognitive learning theories have had much less influence on prescriptive instructional design models than behavioral theories and systems approach principles, the shift from the behaviorist tradition to a science of cognition as the dominant learning theory will likely also occur with respect to prescriptive instructional design models. On the other hand, humanistic approaches are more often placed in complete opposition to other theories and models.

Humanistic Approaches

Advocates of affective psychology and education have questioned the methods of instruction advocated by behavioral and cognitive instructional theorists alike. Proponents of humanistic philosophies of education have also posed questions as to who should set goals for individual students and who should determine individual educational outcomes. It is frequently argued that behavioral and cognitive approaches too readily reflect the goals of the teacher while ignoring the values and ends of students (Maslow, 1968; Snelbecker, 1974; Koetting, 1984).

ROLE OF THE TEACHER AND THE INSTRUCTIONAL DESIGNER

A frequent emphasis in instructional design has been to place extensive reliance on instructional materials for the presentation of content, with greater reliance on teachers for personal guidance and evaluation of students (Dick & Carey, 1985). It has been widely recognized that most of the instructional events employed by a self-instructional multimedia program can also be supplied by a good teacher during teacher conducted instruction (Briggs, 1970; Clark, 1983). However, pre-designed learning resources offer advantages in terms of consistency, efficiency and with some delivery systems, the ability to correct errors for individual students.

The source of decision-making with regard to the prescription of instructional methods and strategies may reside primarily with the teacher or an instructional development team, depending on the pattern of instructional organization. Where no other learning resources are in use the teacher would be responsible for all of the strategies. Where the teacher uses some pre-designed learning resources to facilitate instruction, particular strategies will be employed by the teacher in designing instruction utilizing the resources. Additional strategies may have already been built into the media by instructional developers, and these strategies will facilitate the eventual outcome of the instruction. Where complete instructional systems (only mediated instruction with no teacher interaction) are in use the instructional development team has provided built-in strategies, while a *manager of instruction,* or a management group is responsible for other strategies.

INDIVIDUAL DIFFERENCES AND INSTRUCTIONAL DESIGN

An important concern of instructional psychology has been research on approaches to adapting instruction to individual differences among learners. In order to maximize instructional potential, the aptitude-treatment interaction (ATI) paradigm seeks to locate crucial interactions between instructional treatments and learner aptitudes or traits. Hopefully, this will enable the instructional designer to identify interactions which suggest the prescription of methods on the basis of student characteristics.

There is no universal agreement as to how individual differences might be used for prescribing instructional treatments as a function of cognitive characteristics. A key question concerns whether assigning instructional treatments to improve impotent cognitive processes is preferable to assigning instructional treatments that capitalize on potent cognitive processes (Federico, 1980).

Three rival modes of ATI hypothesizing seek to match learner aptitudes and instructional methods: capitalization, compensation, and remediation (Salomon, 1972; Messick, 1976; Shuell, 1980). Capitalization seeks to discover alternative treatments that capitalize on the strengths of particular kinds of learners. There is not attempt to correct or compensate for learner deficiencies. Each student exercises his or her strongest, and possibly most preferred processes.

The compensation mode fits treatments to the weaknesses of learners. The instruction is designed to do for the learners what they are unable to do for themselves. Remediation relates to situations in which the learner is presented with knowledge or skills which are required for the task,-which the student is capable of learning, and which are required for further progress in learning.

Implementation of any of the above modes for addressing individual differences would necessitate providing appropriate matches of instructional method to the idiosyncratic styles, abilities and interests of students. However, it is necessary to question the economic feasibility of providing the accommodating instruction which would be required to carry out such an extensive program. "Being in the business of producing effective and efficient instruction we are also concerned with the pragmatic question of the extent to which we can afford to accommodate (even recognize) these idiosyncracies" (Smith, 1985, p. 9).

Dramatic evidence from research on the human brain has prompted many educators to seek ways of providing for individual differences based on evidence that the left and right hemispheres of the brain process information differently, with individuals generally favoring a particular hemisphere. Emphasis on highly abstract conceptual activities (left brain dominant) in the schools has led to suggestions that the right brain is being neglected. Thus a call to *educate the right brain* and provide students (especially *right brained* students) with *right brain activities.* However, such ideas overlook increasing evidence regarding the importance of each hemisphere participating in the educational process concurrently, regardless of the subject matter (La Follette, 1984).

While research on the specialized functions of the left and right hemisphere of the brain supports the idea of two different modes of knowing (apprehension and comprehension), there is increasing support for the concept that successful learning involves a synthesis of the processes of both hemispheres. Levy (1983) concluded that the evidence clearly supports the inference that all subject matter engages the specializations of both sides of the brain, and that the overall aim of education should be to guide students toward a deep synthesis of the differing perceptions involved. Each cerebral hemisphere makes essential contributions to human performance by having functions complementary to the other. Thus learning results in collaborative integration of the processes of each side of the brain.

In contrast to systems matching instructional mode to student characteristics, an instructional design approach based on experiential learning theory would attempt to accommodate individual differences by providing learning experiences which would allow each learner to capitalize on his or her strengths for a portion of the time, and to develop proficiency in alternative modes (which are essential for lifelong learning) for a portion of the time.

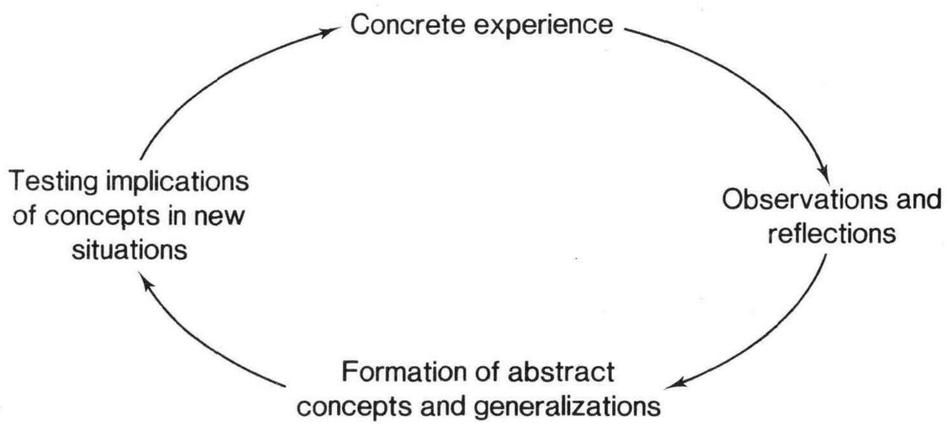
EXPERIENTIAL LEARNING THEORY AS SYNTHESIS

Having evolved from many diverse intellectual traditions including social psychology, philosophy, and cognitive psychology, experiential learning theory (Kolb, 1984) promises to provide a basis for integrating current operational models of instructional design, cognitive processing theory, and concepts of affective educational and psychological theory to provide a holistic integrative approach to designing instructional resources and experiences.

The major traditions of experiential learning which Kolb has synthesized into his descriptive theory of the learning process are those of Kurt Lewin, Jean Piaget, and John Dewey. A substantial debt is also owed to the work of Carl Jung, particulary his concept of psychological types representing different modes of adapting to the world.

Lewin provided the basic analogy for learning as a four-stage cycle (see figure 2). Immediate concrete experience is seen as the basis for observation and reflection. These observations and reflections are used to build generalizations from which new implications for action can be deduced. These implications then guide actions for creating new experiences (Kolb & Fry, 1975; Kolb, 1981; Kolb, 1984).

Figure 2.
The Experiential Learning Model (Kurt Lewin)



From "Learning styles and disciplinary differences" by D. A. Kolb, in A. W.Chickering & Associates, *The modern American college.* Copyright 1981 by Jossey-Bass. Reprinted by permission.

Piaget represented the key to learning as "the mutual interaction of the process of *accommodation* of concepts or schemas to experience in the world and the process of *assimilation* of events and experiences from the world into existing concepts and schemas" (Kolb, 1984, p. 23). It was suggested that a balanced tension between the two processes results in intelligent learning.

Dewey was a forerunner in stressing the linkage between cognitive processes and concrete experiences. He identified experience as including a uniquely combined active and passive element. Early in the present century Dewey stressed the importance of thinking in experience and described thinking as "the accurate and deliberate instituting of connections between what is done and its consequences" (1916, p. 177). In linking thinking with experience and learning, Dewey noted that thinking includes the following steps: the sense of a problem; the observation of conditions; the formation and rational elaboration of a suggested conclusion; and active experimentation.

Experiential learning has frequently been associated with notions of giving academic credit for life experiences; non-classroom learning; and work experience as an integral component of schooling (Keeton & Associates, 1976). In terms of the above, Houle (1976) traced experiential learning's deep traditions back to medieval times and beyond. However, historically the concept has not generally been linked with *all* of learning and a sharp distinction has often been made between *school learning* or *information assimilation* and experiential learning. A plea for closer unity of experience and school-based learning was presented by Dewey (1938). Observing mankind's propensity to think in terms of *either-ors* with no recognition of intermediate possibilities, he noted the existence of a close and essential organic connection between the processes of actual experience and education. Citing the need for a philosophy of education based on a philosophy of experience, Dewey called for a "coherent *theory* of experience, affording a positive direction to selection and organization of appropriate educational methods and materials " (1938, p. 21) in order to give new direction to the tasks facing schools.

The term experiential learning has also been identified with the facilitation of *significant* learning. Carl Rogers, in advocating a humanistic approach to education identified two types of learning (cognitive and experiential); two possible aims for education (to transmit stored knowledge and to nurture the process of discovery) and; two sets of assumptions in education (those implicit in current education and those relevant to significant experiential learning) (Rogers, 1967). There is some evidence that this polarization which tends to pit the cognitive against the affective is becoming less pronounced and that the deep divisions it has caused are healing.

While the cognitive processing research mentioned in the previous section is clearly stressing abstract conceptualization (the aquisition, recall and manipulation of abstract symbols), the direction is toward learning based on increased understanding with experience playing a significant role in the process. In suggesting that learning in schools be reconceived as a generative cognitive process, Wittrock (1977) observed that in this sense, teaching might be described as "the process of organizing and relating new information to the learner's previous experience, stimulating him to construct his own representations for what he is encountering (1977, p. 177). Thus, students learn by active construction of meaning, by reactions which the teacher and pre-designed learning resources induce them to generate.

Pointing out that different instructional theories and perspectives should not be thought of as competing with one another, Reigeluth (1983) identified the need for a synthesis of individual strategy components into models of instruction (each of which would be intended to optimize learning for a different kind of situation). In turn, individual instructional models would be integrated into a comprehensive theory of instruction.

Experiential learning theory provides at least a tentative basis for the development of such a comprehensive theory in that it proposes an approach to education and learning which provides a framework for investigating and strengthening the crucial relationships among schooling, experience, and personal development. Kolb (1984) argues that experiential learning suggests the principles for the conduct of various forms of experiential education as well as for the design of curricula of virtually any subject at any level, due to the underlying nature of the learning process involved.

STRUCTURAL DIMENSIONS OF EXPERIENTIAL LEARNING

Kolb (1981, 1984) has defined learning in the broad sense of aquisition of knowledge as opposed to a narrower psychological sense of modification of behavior. He has equated learning with experiential learning and has provided a concise working definition of learning: "Learning is the process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 38). The underlying structure of Kolb's model results from the intersecting of two distinct dimensions, each of which represents two dialectically opposed adaptive orientations (concrete experience/abstract conceptualization and active experimentation/reflective observation). The structural dimensions underlying the process of experiential learning and the resulting basic knowledge forms are seen in Figure 3.

Figures.
Structural Dimensions Underlying the Process of Experiential Learning and the Resulting Basic Knowledge Forms.

From *Experiential learning: Experience as the source of learning and development,* by D. A. Kolb, copyright 1984 by Prentice-Hall. Reprinted by permission.

Kolb has referred to the abstract/concrete dialectic as *prehension.* It represents two different and opposing processes of taking hold of experience (grasping) in the world. *Grasping* occurs on the concrete/abstract dimension and involves:

a) *comprehension* - reliance on conceptual interpretation and symbolic representation, and;
b) *apprehension* — reliance on the tangible, felt qualities of immediate experience.

The active/ reflective dialectic represents a *transformation* dimension, equivalent to the mode of processing experience. The opposing processes are:

a) *intention* —processing phenomena through internal reflection, and;
b) *extention* — active manipulation of the external world (Kolb, 1984).

It is the combination of how we perceive and how we process our experience that forms the uniqueness of each individual's learning style.

Thus, experiential learning is represented as a four-stage cycle involving four adaptive learning modes — concrete experience, reflective observation, abstract conceptualization, and active experimentation. It is maintained by Kolb that each of the four modes provide equipotent contributions to the learning process. Resolution of the dialectic conflicts among the four modes results in the identification of four basic elemental forms of knowledge, each corresponding to a complementary learning style.

While Kolb emphasizes that individual styles of learning are complex and not easily reducible into simple typologies, he has created an instrument called the Learning Style Inventory (Kolb, 1976) to assess individual learning orientations based on the extent to which people emphasize the four modes of the learning process. Over time, most people develop learning styles that emphasize some learning abilities over others. The basic learning styles, based on the underlying structure of the learning process are:

Divergent:
concrete experience and reflective observation
Assimilative:
abstract conceptualization and reflective observation
Convergent:
abstract conceptualization and active experimentation
Accommodation:
concrete experience and active experimentation

The Learning Style Inventory was developed for use with adults and is not intended for students from Kindergarten through Senior High School levels. It has been used in business, management and training areas, and also as a means of making school teachers aware of their predispositional learning style (Madison Local Schools, 1982).

It is important to recall that experiential learning theory does not reject behavioral and cognitive learning theories. Rather, by identifying different types of knowledge it proposes an accommodation of opposing orientations in a complementary sense. Experiential learning suggests that each individual will emphasize to varying degrees the four elementary modes of the learning process: concrete experience; reflective observation; abstract conceptualization; and active experimentation. Although it is possible to identify positive learning achievements in each of the four modes, "more powerful and adaptive forms of learning emerge when these strategies are used in combination" (Kolb, 1984, p. 65).

It is the combination of all four elementary learning forms which results in the highest level of learning. The learning process in any given instance may be governed by one or all of the modes interacting simultaneously.

EXPERIENTIAL LEARNING AND INSTRUCTIONAL DESIGN MODELS

From the standpoint of descriptive learning theory, Kolb's synthesis of experiential learning theory potentially makes an impressive start toward integration into a comprehensive theory of instruction which accommodates the needs of many seemingly disparate and competing philosophies. Experiences involving the different experiential modes would provide accommodating instruction for learners who favor each learning style, for at least a portion of the time (capitalization). Perhaps even more importantly, experiences in all experiential modes would ultimately lead to improvement for learners who were initially deficient in a given mode (remediation).

Much research and development would need to take place in order to evolve a complete operational model of instructional design from the theory of experiential learning. However, one approach, the *4-Mat* system, developed by Bernice McCarthy represents a system for planning instruction to incorporate experiences related to each of the four learning styles into a given unit (McCarthy, 1980: McCarthy & Leflar, 1983).

The *4-Mat* system differs from other learning style approaches in that it does not attempt to diagnose student's learning styles, nor seek to accommodate their perceptual and processing preferences by prescribing instructional activities which match identified learning styles. Instead, consistent with the experiential learning approach, all students participate in activities in all four adaptive learning modes.

McCarthy's system follows closely that of Kolb, although interestingly she has compared his model with those of six other learning style researchers as well as with Carl Jung's classifications, and demonstrated that all are nearly identical. She stresses a progression from experience, to reflection, to conceptualization, to experimentation, and back to experience (the four adaptive learning modes), thus accommodating a developmental spiral effect while allowing students to perceive and process reality in their most comfortable way part of the time. Most importantly, equal value should be given to all four dimensions, allowing each student the opportunity to refine his or her favored style while experiencing and developing alternative styles.

In addition to incorporating experiences related to each of the four learning styles identified by Kolb, instruction designed using the *4-Mat* system incorporates activity based on techniques to facilitate predominately left brain and predominately right brain processes in each adaptive learning mode. The suggested application of the 4-Mat system is to design each unit to progress in a clock-wise manner through activities involving each learning mode. Activities related to the specializations of the left and right hemispheres of the brain provide further reinforcement for effecting learning through adapting the dialectic tensions on the apprehension/comprehension dimension. The eight resulting steps and suggestions for the type of instructional/learning activity with each step are listed in Figure 4 (see next page).

Application of the 4-Mat system implies that most instructional decisions will be made by a teacher, thus it relates closely to patterns of instructions where a teacher *shares* the instruction with pre-designed learning resources. There are places in the cycle where the students will be more active and other places which suggest greater activity on the part of the teacher or learning resources. It will be noted that Steps 4 and 5 require use of abstract conceptualization processes most representative of cognitive and behavioral theory. Dramatic developments in the areas of Computer Based Instruction and interactive video

Figure 4.
The 4-Mat System.

QUADRANT ONE: **INTEGRATING EXPERIENCE WITH THE SELF**

1. (R) Create a concrete experience
2. (L) Reflect on experience, analyze it
   (Why? Give a Reason)

QUADRANT TWO: **CONCEPT FORMULATION**

3. (R) Integrating the experience into the materials
4. (L) Present the facts/skills
   (What? Teach it to them)

QUADRANT THREE: **PRACTICE AND PERSONALIZATION**

5. (L) Working on defined concepts with prepared materials
6. (R) Creating materials of their own
   (How does this work? Let them try it)

QUADRANT FOUR: **INTEGRATING APPLICATION AND EXPERIENCE**

7. (L) Analyzing for usefulness or application
8. (R) Doing it themselves and sharing what they do with others
   (What can this become? What can I make of this? Let them teach it to themselves and to someone else)

From *The 4-Mat System,* by B. McCarthy, copyright 1980 by Excel, Inc. Adapted by permission.

promise to provide an increasingly useful selection of resources for providing student experiences which guide learners in achieving goals related to abstract conceptualization. The impressive strides in research and theory development mentioned earlier indicate these resources will be increasingly effective. The teacher as instructional designer could select and utilize resources consistent with the learning modes appropriate for each of the steps. Where appropriate the teacher could provide guidance to groups and individuals by serving as a resource, as well as making available selected resources and activities.

Synthesis of operational approaches to experiential learning, for example the 4-Mat system, with current instructional design models appears worthy of serious consideration. The model for designing instruction presented by Dick and Carey (1985) is representative of systems approach models. While it must be comprehended in systemic fashion and viewed as an interactive process, it is necessary to treat individual components of the model in a sequential manner. The model and the related discussion of procedures and techniques is intended to enable an instructional designer to design, produce, evaluate, and revise a module of instruction. Dick and Carey identify the following components in their model: Identify Instructional Goal(s); Conduct Instructional Analysis; Identify Entry Behaviors, Characteristics; Write Performance Objectives; Develop Criterion-Referenced Test Items; Develop Instructional Strategy; Develop and Select Instructional Materials; Design and Conduct Formative Evaluation; and Revise Instruction (Dick & Carey, 1985).

While integration of the 4-Mat system with the systems approach instructional design model would need to take place with respect to all components of the model, the *Developing Instructional Strategy* component shows particular promise.

Dick and Carey identify five major components in an instructional strategy:

1) preinstructional activities;
2) information presentation;
3) student participation;
4) testing; and
5) follow-through (1985, p. 136).

As the above five components are subdivided further, they bear a nearly one-to-one relationship with the nine events of instruction identified by Gagne and Briggs (1979):

1) gaining attention;
2) informing the learner of the objective;
3) stimulating recall of prerequisite learnings;
4) presenting the stimulus material;
5) providing *learning guidance;*
6) eliciting the performance;
7) providing feedback about performance correctness;
8) assessing the performance; and
9) enhancing retention and transfer (p. 170).

Despite the fact that they were derived in part from different underlying theoretical premises, the components of the 4-Mat system model are relatively similar to those of the instructional strategy component of Dick and Carey's model and to the instructional events presented by Gagne and Briggs (La Follette, 1985). Figure 5 suggests relationships among the three.

Numerous sample *lesson plans* for implementing the 4-Mat approach are presently available (McCarthy, 1980; Madison Local Schools, 1982; McCarthy and Leflar, 1983). However, a necessary step before teachers could be expected to make widespread use of the model would be the compilation of *banks* of example experiences for each step in the cycle.

Figure 5.
Comparison of the 4-Mat System, an Instructional Strategy Format, and Instructional Events.

4-MAT SYSTEM (McCarthy)	**INSTRUCTIONAL STRATEGY** (Dick and Carey)		**INSTRUCTIONAL EVENTS** (Gagne[1] & Briggs)
	Instructional Activity		
(1),(2)	Preinstructional Activity	Motivation	1
		Objectives	2
		Prerequisite Skills	3
(4)	Presenting Information	Content Presentation	4
(3)		Examples	5
(5)	Student Participation and Embedded Tests	Practice	6
		Feedback	7
(6), (7), (8)	Follow-Through Activities	Remediation	8, 9
		Enrichment	

Material from *The systematic design of instruction,* by W. Dick and L. Carey, copyright 1978 by Scott, Foresman. Adapted by permission.

SUMMARY

Recent decades have seen a shift from a behaviorist tradition to a cognitive approach as the dominant theory of learning. However, prescriptive models of the instructional design process have been slow to follow the shift. At the same time, proponents of the affective component of education have denounced perceived overemphasis on outcomes requiring a high degree of abstract conceptualization.

David Kolb's synthesis of experiential learning theory has been proposed as a promising theoretical foundation upon which to develop an operational model for designing instructional experiences which will capitalize on a student's own unique learning style, and also provide experiences for developing other learning abilities. Research and developmental activities dedicated to the identification of successful approaches to achieving a synthesis of experiential learning theory and contemporary instructional design models appear promising.

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Profile

Graphics Creation for Television Using the Sony SMC-70G Microcomputer

Ross Mutton

Abstract: Carleton University operates an instructional television channel across the Ottawa cable companies. There was a need to modernize the equipment used for feeding course and University activity information over the channel when not broadcasting telecourses. This article examines the selection process and describes the attributes and limitations of the microcomputer system eventually selected.

Carleton University operates an instructional television channel, ITV, feeding the two cable companies serving the Greater Ottawa area. This channel broadcasts both live lectures from a classroom equipped for television transmission, and pre-packaged telecourses of credit courses offered by the university. This accounts for an average of 30 hours of programming per week during the academic year, leaving considerable time per week when the channel can be used for providing information to the telecourse students and the general public on both messages associated with courses and details of activities occurring at the university.

This function was performed using a *Message Wheel,* a device manufactured by Telemation consisting of a large drum capable of holding 24 three-by-five cards which rotated past a black-and-white camera. Thus, it was necessary to manually type messages on cards and insert them into the drum. If not all slots were filled, there was a digital clock mounted behind the wheel which would show through the empty slots, displaying the time.

There were two major problems with this system, besides the fact that it was a museum piece. The system was limited to a total of 24 messages, not enough for the number of activities through most of the academic year. Also, the equipment was not reliable enough to operate unattended. For the bulk of the available time we were unable to run the information system.

Selecting an Electronic System

It seemed appropriate to upgrade to an electronic system with more storage and 24-hour

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reliability. An initial choice was a character generator. But, it was useful to investigate new technologies such as micro computers and Telidon which permitted not only text display, but also the creation of colour graphics, providing a more interesting and pleasing display.

At the time of this search (Autumn 1983), there were two serious contenders for the system: the Sony SMC-70G graphics creation package and the Apple-based Formic system employing Telidon technology. Our criteria were: 1) the production of a broadcast standard genlockable signal that could be integrated with other video sources and transmitted, 2) availability of font styles and sizes that were legible through cable transmission, 3) the capacity of the system to store electronic pages, and 4) the capability to produce graphic images.

The comparison between the two systems broke down as follows by criteria:

1) The Sony system was designed as a television system tool that produced a standard broadcast NTSC signal that could be easily adjusted and integrated with existing video equipment. The Formic required a special Telidon decoder in conjunction with an RGB/NTSC encoder, an expensive addition.

2) Both systems had a variety of font styles and sizes. The basic font with the Formic system was a small block-style upper case font. Additional fonts were slower to create and display.The Sony system incorporated five basic fonts which were easy to create and display.

3) The Formic system had more than enough capacity to store the required number of pages within the micro. The Sony required a hard disc option. However, continuous 24-hour access from a floppy disc was not as reliable an alternative as hard disc access.

4) The Formic system produced excellent graphics, with a palette of over 4,000 colours, 16 available at one time. The Sony system produced medium resolution graphics with a palette of 16 colours, all available at the same time.

The Sony system was selected because of its ability to produce broadcast standard video, its ease of producing a variety of fonts, and its flexibility to incorporate into an existing studio production facility.

The system purchased consists of the following:

A graphics creation work station (see Figure 1 on next page)

- 1 Sony SMC-70G micro computer, complete with dual micro floppy disc and NTSC Superimposer
- 1 Sumagraphics Bit Pad
- 1 Panasonic Monitor

TOTAL COST - $8,400.00

A graphics display station

- 1 Sony SMC-70G micro computer, complete with dual micro floppy disc and NTSC Superimposer
- 1 Corvis Winchester type 5.9 MB hard disc

TOTAL COST - $9,800.00

Figure 1.
Graphics Creation Workstation Consisting of Sony Microcomputer, RGB Monitor and Graphics Tablet.

The display station is the heart of the system, available for feeding the channel on a 24-hour basis. The 5.9 MB hard disc is used to provide adequate capacity (up to 120 pages of information) and reliability in a continuous 24-hour operation. The work station permits creation of graphics while the display station is in operation. It includes a bit pad which artists find more versatile than the keyboard for free-hand drawing and tracing. The work station also feeds genlocked video into the production switcher plus key level video into the downstream keyer so that it can be used as a video source or character generator in production, when it is not being used for the creation of graphics.

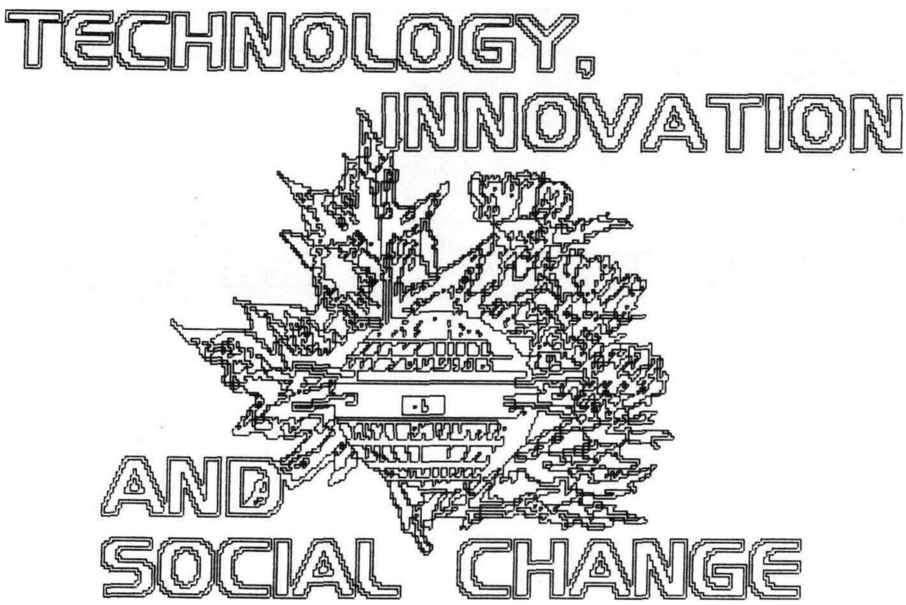
System Operation

The system on ITV is used to display information concerning registration, ITV course information, and non-academic and academic-related events that are of interest to students and the general public. The system runs on the channel whenever we are not broadcasting course material. Most of the material is text. We have thus designed a variety of simple but attractive backgrounds identifying Carleton University, over which we can print the text. The creation of such pages averages about 10 minutes each. Permanent pages referring to services, plus pages regarding special events are designed with graphic enhancement. They provide a visual highlight and hopefully draw attention to special events. We can select the display time and sequence of pages.

Production

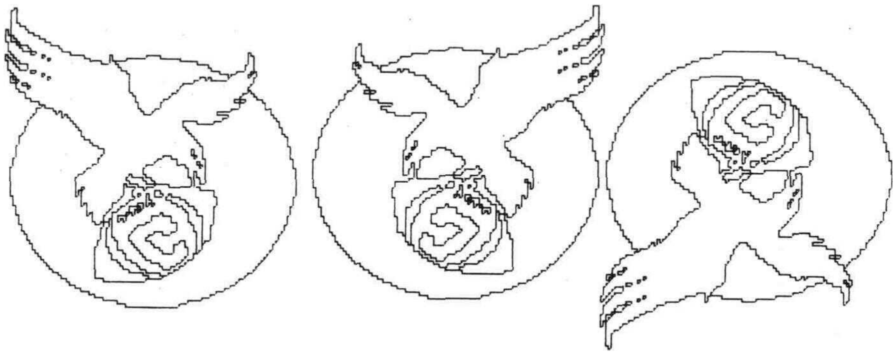
The SMC-70G has been used in two ways for television production. By feeding the key output to the switcher, it is used as a character generator with six to eight available fonts. In addition, we can record the video from the SMC-70G as another video source through our switcher. We have used it for the production of high-tech computer style graphics (See Figure 2), and for graphs and charts. An advantage of using this system for producing graphics for television is that through designing successive overlays of information, the graphic material can be built up on the screen through editing and the use of wipes or dissolves through the switcher. This is particularly effective with graphs and charts.

Figure 2.
Sample of High-Tech Computer Graphics.



The Sony SMC-70G is CPM based. We use two software packages, primarily in the production of graphics. The first is Credit, or Graphics Editor. This program permits the creation of the illustrated graphics including a choice of 16 colours. The program is designed so that this creation occurs within the safe title area of the television screen. A coloured border completes the image to the outer limits of the scanning area. The software permits the creation of graphic images through the ability to produce lines, boxes, filled boxes, circles and filled circle functions. Through the use of the bit pad with either a mouse or a light pen, graphics can be drawn free-hand and coloured using the fill function. The artwork can be "cleaned up" by expanding the scale of the work, manipulating the individual pixels, and reducing the image once again to original scale. The graphics may be composed of 16 different colours, capable of simultaneous display. Any portion of the material may be moved, rotated (See Figure 3), copied or scaled up or down in size. Through overlay, you may superimpose one image over another.

Figures.
Sample of Rotated Graphic.



The other software package is Videotitler which permits the creation of text. The package comes with six pre-designed fonts (See Figure 4), five of which have three sizes, the sixth has only one size. The typefaces compare to Letraset's Century Schoolbook, Helvetica, Rockwell and Helvetica Italic. In addition, it is possible to create your own fonts and store them in the software. There is space for two fonts over and above the six fonts produced by Sony. It is possible to determine the spacing between each letter, outline or drop shadow a letter to a given thickness, and determine the colour of the letter and the shadow or outline independently. You may move and centre lines. By using a combination of Credit and Videotitler, we are able to produce pages with both visual graphics and textual information.

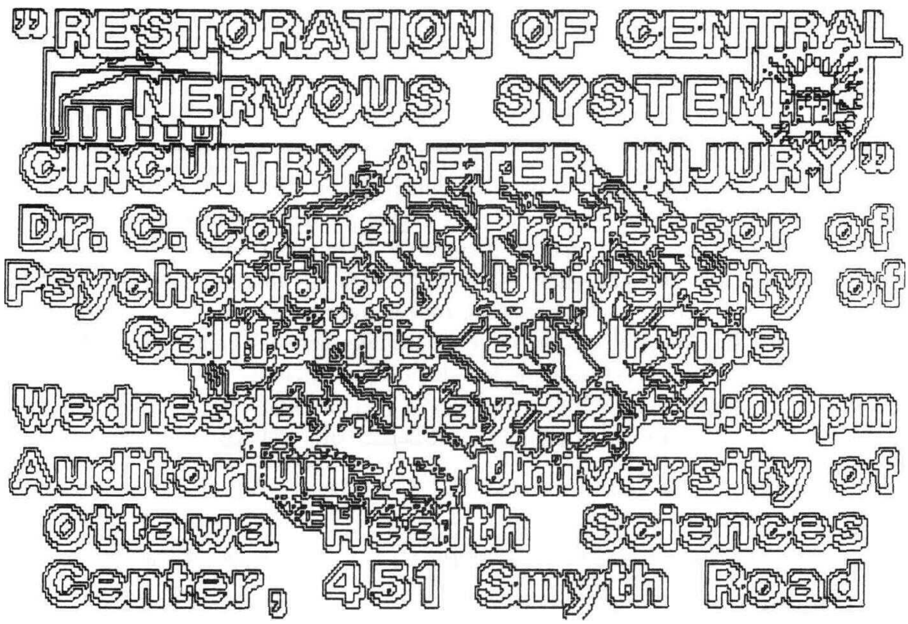
Operational Considerations

In working with this system, we have learned a few operational *do's* and *don'ts.* When

Figure 4.
Sample of Six Fonts.

creating pages, always look at the final result on video before deciding the work is complete. There are differences in both colour and resolution between the picture on an RGB monitor and that on a standard video monitor. Since these graphics are going to be seen in the video mode by 1QO% of our viewers, that must be the final test. The same applies to use in video production. Secondly, don't get carried away with the graphic creation ability when displaying text information. The graphics should enhance. Overuse results in a very busy display (See Figure 5) that detracts from the text, or in some cases makes the text almost impossible to read. The system works best with short and concise information, as is true with any textual information on a television screen.

Figure 5.
Sample Graphic That is Too Busy.



In comparison to a character generator, the Sony SMC-70G has some drawbacks. It is more time consuming when producing pages of text for short term storage and use. Its access time from page to page is not as fast. Close inspection of the curved edges of the character will reveal a jaggedness. However, the system does permit long term storage of numerous pages of text in a variety of fonts. Through the superimpose mode, the user is able to superimpose multicoloured text over video so that there is no need to tie up a switcher to insert keys. The system provides considerable flexibility and storage capacity at a moderate price. And of course, it offers much more than a character generator in the capability to produce graphic displays.

In comparison to Telidon technology, it does not have the finite detail nor the almost limitless variety of colours available in the NAPLPS (North American Presentation Level Protocol Syntax) standard. It does produce RGB, and genlockable video, making it a production tool. At the time of our purchase, to produce video from Telidon required special equipment. To produce Telidon fonts with a drop shadow effect is a time-consuming process.

Summary

In summary, we have perceived the following benefits of the Sony SMC-70G system:

1) the use of the various fonts for text production is easy and versatile;
2) the entire system is simple to operate;
3) both broadcast standard RGB and genlocked video are available for use in television production and distribution;
4) software is continuing to be developed, permitting interface with a variety of Sony video hardware;
5) the storage of information is easy and reliable; and
6) the system is relatively economical.

In addition, we have the following criticisms:

1) page production is a slower process than with a television character generator;
2) the quality of the video from the NTSC encoder could be better, though this unit provided respectable quality considering price;
3) in the display mode, the border surround does not wipe in with the rest of the video information; and
4) it is limited in the number of colour choices and graphic resolution, understandably a function of its cost.

For our purposes at Carleton University, we have found the system to be particularly useful and effective in displaying information about events occurring at the university to approximately 125,000 homes in the Greater Ottawa area. In addition, we have found it to be a useful production tool, and look forward to future software developments such as editing control software. Because we are dealing with software as well as hardware, unlike previous video equipment, this technology is capable of becoming even more versatile with age.

Microware Review

Len Proctor

Computereyes Video Acquisition System

The COMPUTEREYES Video Acquisition System is an inexpensive accessory for the Apple II series of personal computers that can translate any standard video signal into an Apple hi-res screen image. To the user this means that they can now capture and print out on paper or on disk realistic images from a variety of video sources such as video tape recorders, video disk players and video cameras. The relative ease with which this may be done facilitates the production of both paper and computer-based materials to support instruction. In addition, accessory utility programs are also available to adapt the image produced by COMPUTEREYES for use with other popular graphics programs such as Print Shop, Newsroom or Mouse Paint.

Contrary to the requirements of most of the peripherals available for the Apple II, COMPUTEREYES does not use an expansion slot. Instead, after the video signal has been passed from the source to the COMPUTEREYES hardware, the hardware box is connected with a ribbon cable to the 16-pin Game I/O socket in Apple's motherboard. Only two video signal adjustments are required. They are image brightness and synchronization. The few steps required for making these adjustments is detailed in a concise and well written manual.

The menu driven system software provided by the manufacturer serves several functions. It controls the initial set-up of the system, the digitization of computer images and the storage or retrieval of images from the disk. Initial set-up or sync adjustment is usually only required only at the beginning of each session in which the equipment is used.

Once this minor task has been completed, the system is ready to capture an image. If a camera such as an aging monochrome port-a-pack is the source of choice, simply point it at the subject, focus and frame the image in the standard manner. Once the image is in place, a choice of three levels of digital capture are available. They are normal, 4-level and 8-level. Normal mode, like high contrast litho film provides only a high contrast black or white line, no half-tones. The 4 and 8-level capture modes provide a limited number of synthesized levels of grey. In this case, the system brightness, camera aperture and subject lighting have to be very carefully adjusted in order to obtain a good multi-level image. Unlike the adjustment for synchronization, this adjustment can be a lengthy, time consuming trial and error process.

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In the normal capture mode, the scan time is about five seconds. The 4-level mode takes about 22 seconds and the 8-level about 45 seconds. Thus, just as in the case of photographic time exposures, the less the subject moves while the image is being digitized, the sharper the graphic will be.

Color information in the video signal is ignored except in the case where a color monitor is used to display the graphic. Because of the way that the Apple handles color and color graphics, the results may be confusing. This is a monochrome system and consequently works best with a monochrome screen.

COMPUTEREYES is available from Digital Vision, Inc., 14 Oak Street, Suite 2, Needham, MA 02192. The cost of the basic package, i.e., interface and software is $130.00 U.S. funds. The cost of the package including a non-viewfinder type camera is $400.00 U.S. Double high-res, Print Shop and Newsroom Utility disks are about $15.00 U.S. each.

From the Media Periodicals

Richard Ellis, Editor

This column is a listing of articles that have appeared recently in the literature of educational communication and technology.

BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY, 17 (2), May, 1986.

Ikebuzor, N. A. "Appropriate instructional media selection (AIMS): An issue in educational technology in the Nigerian school system."
Siann, G., & Maclean, H. "Computers and children of primary school age: Issues and questions."
Barker, P. "A practical introduction to authoring for computer-assisted instruction. Part 6: Interactive audio."

COMPUTERS IN EDUCATION, 3 (10), June, 1986.

Allan, R. "World Congress report."
Galley, W. "Microcomputers in administration, part III: The future."
Lamoureux, R. D. "Living literature in the classroom: Part III."
LeBel, C. "Turtles in space."
Nicklin, R. C. "A trilling sensor: Studying the force of music."

EDUCATIONAL TECHNOLOGY, 26 (8), August, 1986.

Davidove, E. A. "Design and production of interactive videodisc programming."
McMeen, G. R. "Modern technology in education: From teaching machine to microcomputers and student response systems."
McCutcheon, J. W. "What influences the content of introductory educational media courses?"
Powell, J. T. "What we don't know about the influence of television."
Stowitschek, J. J., et al. "Inservice training via telecommunications: Out of the workshop and into the classroom."
Zelman, S. "Motivational differences in learning about computer hardware and software: Implications of students ideas about intelligence."

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EDUCATIONAL TECHNOLOGY, 26 (7), July, 1986.

Dear B. L. "Artificial intelligence techniques: Applications for courseware development."
Andrews, D. H., & Windmueller, H. W. "Lock-step vs. free-play maintenance training devices: Definitions and issues."
Rosen, D. "History in the making: A report from Microsoft's First International Conference on CD ROM."
Maddox, C. D., & Cummings, R. E. "Educational computing at the crossroads: Type I or Type II uses to predominate?"
Manion, M. H. "Computers and behavior disordered students: A rationale and review of the literature."
Mevarech, Z. R. "Time engagement and achievement in CAI."
Zhang, C. D. "Computer-based education in China."

EDUCATIONAL TECHNOLOGY, 26 (6), June, 1986.

Waggoner, M. D., & Goldberg, A. L. "A forecast for technology and education: The report of a computer conferencing Delphi."
Martin, B. L. "Aesthetics and media: Implications for the design of instruction."
Costanzo, W. V. "Reading interactive fiction: Implications of a new literary genre."
Smith, P. "Low-cost simulations: The impossible dream revisited."
Kozma, R. B. "Present and future computer courseware authoring systems."

INTERNATIONAL JOURNAL OF INSTRUCTIONAL MEDIA, 13 (3), 1986.

Adams, D. M. "How telecommunications networks are changing our perceptions of the world."
Adams, D. M., et al. "The impact of new computer-controlled electronic media on literacy: Serving science and the humanities."
Manning, D. T. "Health professional students' personality changes during training within a mediated curriculum."
Streit, L. D., & Stern, S. "From trainer to facilitator."
Rehman, S. N., & Hanks, W. E. "Using the subscriber as a tool for programming on a student-managed cable T.V. channel."
Seidman, S. A. "An instructional technologist looks at the curriculum development field."
Hortin, J. A. "Further research on the visual puzzles test."
Cooper, B. L. "Sequel songs and response recordings: The answer record in modern American music, 1950-1985."

INTERNATIONAL JOURNAL OF INSTRUCTIONAL MEDIA, 13 (2), 1986.

Lippert, H. T., et al. "CAI program for remedial language and mathematics training for allied health trainees."
Hefzallah, I. M. "The why of studying critical viewing."
Hezel, R. T. "Effects of televised emotional appeals on message recall."

Dwyer, C. A. "The physiological and emotional effects of visual stimuli on the human learner: A cause of concern?"
Hannafin, M. J. "The development of a media-based procedure to identify the spontaneous learning strategies of children."
Moscow, M., & Ledford, B. "A theoretical treatment and review of advance organizer media research."
McDonald, J. R. "Rockin[1] in the classroom: A literacy alternative."

JOURNAL OF COMPUTER-BASED INSTRUCTION, 13 (2), Spring, 1986.

Harris, S. D., & Owens, J. M. "Some critical factors that limit the effectiveness of machine intelligence technology in military systems applications."
Matre, N. V., & Robinson, C. R. "The automated maneuvering board training system: An inprogress implementation evaluation."
Pipitone, F. "An expert system for electronics troubleshooting based on qualitative causal reasoning."
Gott, S. P., et al. "Mode of technical competence for intelligent tutoring systems."
Richardson, J. J., & Jackson, T. E. "Developing the technology for intelligent maintenance advisors."
Pliske, D. B., & Psotka, J. "Exploratory programming environments for designing ICAI."

MEDIA IN EDUCATION AND DEVELOPMENT, 19 (2), June, 1986.

Green, M. "Radio GNR: Western Australia. "
Nicholson, R. "Better teaching of science and technology through educational innovation."
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Are there special topics you would like to see in *CJEC* columns?

If so, send your ideas or submissions directly to the column editors.

MICROWARE REVIEW addresses topics related to the use of microcomputer software.
Send ideas or topics to:

Dr. Len Proctor
College of Education
University of Saskatchewan
Saskatoon, SK S7N OWO

BOOK REVIEWS reviews recent books in the area of educational communication and technology.
Send review submissions (six page maximum) or titles of books to be reviewed to:

Ms. Suzanne Daningburg
Department of Education
Concordia University
1455 de Maisonneuve Blvd. W.
Montreal, PQ H3G IMS

Mediography

Nancy L. Lane, Editor

This column contains titles and a brief annotation of media products that are currently available on the market. In each issue of *CJEC, a* different theme is researched.

Media for Telecourses

As distance education becomes more and more of a reality, the need for media support for courses increases. Listed below are some of the series currently available, designed for credit and non-credit activities. All of the distributors can be contacted regarding additional programs. I have limited this column to information about new programs. Support material varies from complex texts, to study guides, to programs alone.

THE AFRICANS

9-60 min. programs, 1986, WETA & BBC/VEC. The life and history of Africa is examined in this series.

BEYOND THE MECHANICAL UNIVERSE

26-30 min. programs, 1987, COAST/MAGLANT. Produced by the California Institute of Technology, this series is a sequel to the Physics series — "The Mechanical Universe".

BRIDGE BASICS

7-29 min. programs, 1986, KET/Marlin. In this series the game of bridge is explained. Different steps are demonstrated. With Mary McVey. A second series is titled - "Play Bridge".

EDUCATION FOR ADULTS

8-25 min. programs, 198?, Open U/ITF. The four blocks covered by this course are Concepts of Adult Education; Adult Learning; Individual, Group and Community; The institutions, Present and Future. Course E355.

Nancy L. Lane is head of the Distribution Group for Communication Systems, The University of Manitoba, Winnipeg, Manitoba.

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ENGINEERING PRODUCT DESIGN

8-25 min. programs, 198?, Open U/1TF. This series explores design in an industrial and commercial, setting. Course T392.

EYES ON THE PRIZE - AMERICA'S CIVIL RIGHTS YEARS

6-60 min. programs, 1986, PBS. This series covers the time period 1954-65 using archival footage and present-day interviews.

FOCUS ON SOCCER - INTERNATIONAL COACHING SERIES

7-27 min. programs, 198?, Omega. With top professional players as hosts, this series examines the skills, techniques and tactics of the game.

HEART OF THE DRAGON

12-51 min. programs, 1984, TIML/Marlin. The subject of this series is life in China. The series analyzes the Chinese approach to life and compares it to the Western way.

IT'S YOUR WELFARE

13-30 min. programs, 1986, Laurier U/MAGLANT. Social welfare in Canada is the subject of this series.

MODERN ART AND MODERNISM; MANET TO POLLUCK

19-25 min. programs, 198?, Open U/ITF, This course covers the history of modern art, theories and interpretation. Course A315.

MONDAYS, MARBLES AND CHALK

This series was designed for teachers to develop classroom management and discipline techniques.

THE QUEST FOR PEACE

30-30 min. programs, 1984-5, MAGLANT. In this modern history series, world experts give their views on peace in the nuclear age.

SCIENCE AND CULTURE IN THE WESTERN TRADITION

13-30 min. programs, 1987, COAST/MAGLANT. History, culture, science - this fascinating series explores the western tradition.

Book Reviews

Suzanne Daningburg, Editor

Expert Systems, by Paul Harmon and David King. John Wiley and Sons, Inc., New York, NY, 1985. 283 pages, $21.00 (Canadian).

Reviewed by Kimiz Dalkir

While the emerging technology of artificial intelligence is of general interest to educational technology, this particular book is especially relevant as it is one of the few to make an explicit link between the two fields. The senior author, an instructional designer turned management consultant, provides a different perspective on the often Computer Science dominated literature on artificial intelligence. I highly recommend this book to anyone wishing an introduction to expert systems, or to anyone who wonders how Educational Technology can fit in with and best benefit from this new field.

Expert systems have enormous potential applications in education. However, these are usually only briefly alluded to in most books, and usually only within the restricted context of computer-aided instruction. Despite the subtitle, Artificial Intelligence in Business, which implies business applications, the scope is really quite diverse. As effectively stated in the forward:

> Everyone in business, from trainer to chief executive, must daily face problem solving and decision making based on extensive but incomplete, uncertain and even contradictory data and knowledge.

In short, there is something for everyone in this book and educational technologists can read through with a view towards adding expert systems to their already substantial repertoire of tools. One can also consider the field of artificial intelligence as an extension of the potential field of practice of Educational Technology. The authors point out that, given the shortage of people formally trained in the field, it is best to hire individuals with similar experience but in more traditional jobs. The three specific groups identified are: project managers, technical writers and instructional designers.

A broad overview of artificial intelligence, its (brief) history and potential applications are included in the first section, with particular emphasis on productivity and training issues. A good distinction is made between expert systems and knowledge-based systems, a boundary that is often blurred in the literature. An expert system is an embodiment of one or many experts' knowledge and expertise, in a particular domain. As such, it requires minimal expertise on the part of the user. The expert system is a mechanized consultant for problem solving. A knowledge-based system, on the other-hand, has much less inherent expertise.Thus, more know-how is required on the part of the user. In fact, such systems can often be used as a reference tool by an expert.

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Training is identified as a good field for expert systems applications, since both training and expert systems require a high degree of expertise confined to a limited area of knowledge and/or skill. Expert systems can be used to decrease the amount of on-the-job-supervision, and consultations with manuals and with experts. The authors are less successful with their contention that expert systems are free of human biases, however. An expert system can be just as biased as any human expert because it is human knowledge and expertise that is modelled in the system. The old maxim "garbage-in-garbage-out" is equally valid whether applied to conventional programs or expert systems.

This selection does a good job of outlining the basic concepts and techniques of artificial intelligence and of expert systems, referring to MYCIN, an expert system to diagnose bacterial infections, as the standard system. This section goes beyond the standard introductions to expert systems, however, by tackling some of the thornier cognitive issues involved. There is a chapter on human problem solving, which addresses the question of where expertise comes into play and how analogous human and machine information processing really are. The complexities of expert systems are directly related to the complexities of problem solving strategies and cognitive functions in humans.

The authors delve further into the cognitive foundations of artificial intelligence by proposing a quantitative model of expertise, along with a very useful rule of thumb to ascertain whether or not expertise exists for a given area. This model incorporates a number of intriguing ideas, including a ten-year minimum requirement for building up expertise (at a rate of seven seconds per chunk) and a 70 millisecond period of time required to access any chunk of information once it is in long-term memory. These points, together with the more widely known limit of 5 to 7 chunks in short-term memory at any one time, are used to suggest that while there is no apparent limit on the amount of information that can be stored, there are limits on accessing this information (or remembering). Thus expertise consists not only of knowledge, but of knowledge access methods.

Using this premise, then, different knowledge representation and inference methodologies can be seen in a different light. A knowledge representation is the structuring and internal representation of all of the facts and rules of the application domain in an expert system. The inference strategy is how the system makes use of this knowledge base in order to answer queries and come up with recommendations. One interesting train of thought is to compare the search strategies used to solve problems or answer questions in human learners. For example, depth-first search will follow a promising branch of the knowledge tree to its end, then start over with another if the first was unsatisfactory, while breadth-first searching will try out several branches first and then follow the best one to its end. This may be analogous to learners who prefer to have an overall view of a subject matter first in contrast to individuals who prefer the building block approach to learning.

A similar analysis can be carried out for the two types of knowledge that can be represented in expert systems: deep and surface. Deep knowledge consists of first principles, axioms, facts and so on. This is analogous to school or textbook knowledge and is to be found in novices or experts confronted with a new type of problem. Surface knowledge is "compiled" in that it consists of heuristics or rules of thumb, judgment, intuition and so on. This is the core of expertise and is often acquired from a mentor or through experience.

The second section discusses expert system languages, tools and systems that are commercially available or under development. There is a good multi-dimensional taxonomy of artificial languages and tools, in addition to a useful checklist to evaluate such tools. Approximately fifteen tools are discussed in some detail, including an overview, the knowledge representation and inference strategy used, the hardware required to implement it and the purchase price. This provides the reader with a good idea as to what is available and how to pick and choose among them.

Section 3 is a step-by-step guide to designing a small expert system, and more general guidelines on how to go about designing larger systems. A training media advisor is used as an example of a small system, with the complete program provided in M1 (an expert system development package). This example involves identifying the needs of trainees, simulating the job performance, identifying instructional factors to be considered and the budget constraints to be respected, in order to recommend the most cost-effective media to use for a particular training task. This section will thus be of particular interest to instructional designers.

Section 4 goes on to provide an overall view of the expert system market: where will expert systems be needed, by whom, and so on. The commercialization prospects of artificial intelligence and expected trends for the next five years are discussed. This section is geared more toward the entrepreneur who is interested in the business of developing and marketing expert system tools and applications, as well as consultants, who may wish to identify areas where their services are likely to be required.

The final section contains an excellent chapter on expert systems in training, which also deals with a number of issues that are are fundamental to educational technology. Among these are the variety of knowledge types that exist and their relationship to instructional strategies. A spectrum is proposed, with education (conceptual level) at one end, performance aids (specific task level) at the other, and training (procedural level) roughly in the middle. This is a good treatment of the often vague terms used in education, including "education" and "training." The authors identify three approaches to teaching, based on this spectrum:

1) to provide conceptual principles that allow the learner to think in abstract terms — *education* (e.g., sending a promising manager back to school to obtain anMBA;
2) to provide some theoretical information, but only within the context of carrying out a particular specified goal - *training* (e.g., sending an employee to a workshop or seminar to acquire particular techniques); and
3) to provide actual tools and a minimal amount of information to allow an employee to carry out a particular task — *job aid* (e.g., giving someone a computer and spreadsheet package to generate the *right* answer.

The authors thus make a distinction between education and training based on both the broadness of the instructional domain, with education having a more global realm than training which has a limited subset of this subject area, and based on the nature of the output (i.e., the individual who is taught). The trained person is much easier to identify than the educated one, which poses problems in defining the objective of education. If someone is successfully trained, then he or she is now capable of carrying out a particular job that they were not able to do before.

Some examples of specific training expert systems developed to date are also described in this section, including:

1) STEAMER - computer-assisted instruction to teach Naval officers how to run a ship's steam propulsion plant;
2) DEBUGGY - to identify student errors in solving math problems;
3) GUIDON - a tutorial on diagnosing bacterial infections (MYCIN rearranged);
4) DELTA - assists mechanics in diagnosing and repairing train engines; and
5) PUFF - a pulmonary diagnosis instructional system.

In general, I found this book to be quite interesting to read, with many excellent diagrams, figures, tables and graphs to complement the points raised in the text. The overview of expert systems is a good introduction to the subject, although a more balanced view, pointing out the limitations of expert systems and common pitfalls in their development and use, would have been preferable. The reader should thus maintain a healthy degree of skepticism regarding any blanket statements extolling the virtues of these systems.

There are three appendices which may also prove quite useful. The first is a glossary of the terms prevalent in any artificial intelligence publication. Another is a list of companies involved in expert system research, along with their addresses and contact persons to write to if the reader is interested in further information. The annotated bibliography at the end of is also a good starting point for anyone interested in pursuing the subject further, as I hope many will. It is likely that if any synergistic association is to formed between artificial intelligence and educational technology, it will be at the initiative of the latter, instead of the leisure of the former.

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Information for Authors

General Policies. *CJEC* welcomes papers on all aspects of educational communication and technology. Topics include, but are not limited to: media and computer applications in education, learning resource centers, communication and instructional theory, instructional design, simulation, gaming and other aspects of the use of technology in the learning process. These may take the form of reviews of literature, descriptions of approaches or procedures, descriptions of new applications, theoretical discussions and reports of research. Manuscripts may fall into one of two classes: **General,** dealing with a topic or issue at a general level (although reference to specifics instances or examples may be included), and **Profiles,** dealing with or describing only a specific instance of an approach, technique, program, project, etc. A Profile may be thought of as a descriptive case study. Most manuscripts dealing with a topic in general should include reference to supportive literature, while manuscripts submitted to the Profile category may or may not. The Editor reserves the right to change the designation of a manuscript or to make a designation, if none has been made previously by the author. Authors interested in determining the suitability of materials should consult past issues of *CJEC* or contact the Editor.

All manuscripts received by the Editor (either general or profile) will be judged for suitability, contribution, accuracy, etc. by a panel of anonymous reviewers designated at the time of submission. Normally, the review process requires about six weeks. There are no deadlines for the submission of manuscripts. Address manuscripts and editorial correspondence to: Dr. Robert M. Bernard, H-549, Concordia University, 1455 de Maisonneuve Blvd. W., Montreal, PQ, H3G 1M8.

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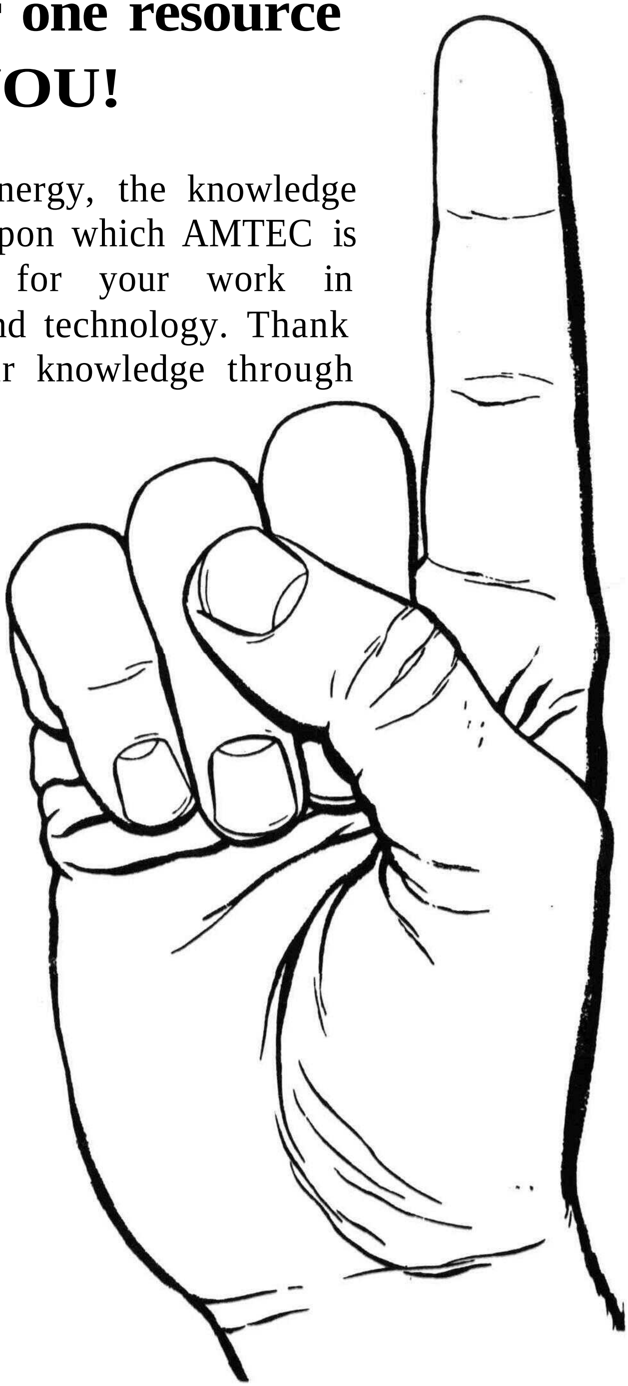

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