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# Conversation Theory and Second Language Lexical Acquisition

Yu Miao
Gary M, Boyd

**Abstract:** Adult second language learners often comprehend second language lexical Items by transferring the conceptual meaning of first language equivalents. Since translation equivalents between two languages often only partially overlap in meaning, learners' acquisition of lexical Items must evolve from the Initial transferred meaning to the target language conceptual meaning. In this paper, a semantic perspective is adopted in analyzing what Is Involved in L2 lexical learning, and a number of Ideas from Pask's conversation theory such as participants (trans-body and intra-body 'p' individuals), self organization, learner In conversation and coherence are applied to provide a cybernetic systemic description of the L2 lexical learning process. Some insights are gained into instructional design issues, control and adaptiveness in teaching, and fossilization In second language learning.

**Resume:** Pour comprendre le sens des elements lexicologiques d'une langue seconde l'etudiant adulte dolt souvent faire appel au sens conceptuel des equivalents de sa propre langue. Comme les significations des equivalents ne se chevauchent souvent que partiellement d'une langue a I'autre, I'acquisition des elements lexicologiques doit evoluer a partir du sens transfere initialement au sens conceptuel de la langue d'arrivee. C'est dans une perspective semantique que nous analysons ce que comporte I'apprentissage d'un deuxleme lexique L2. Certains concepts decoulant de la Theorie Conversationnelle de Gordon Pask, entre autres les trans-corps et intra-corps des Indivldus 'p' (trans-body and intra-body 'p' Indivuals), I'auto-organisation et I'etudiant en conversation et en coherence sont utilises pour apporter une description cybernetique systemique au processus d'apprentissage du lexique L2. Des eclairclssementssont apportessur les questions concernant la conception du materiel didactique, le controle et I'adaptation pedagogiques et la fossilisatlon dans I'apprentissage d'une langue seconde.

Learning second language (L2) lexical items is not simply a matter of acquiring L2 lexical forms. It involves acquiring the L2 conceptual system underlying the L2 lexical system. The learning process is further complicated by the fact that learners transfer first language (LI) conceptual meaning to L2 translation equivalents, which overlap with and differ from the LI lexical items in numerous ways. The learners' task consists of traversing the interlanguage stages (Selinker, 1972) and emerging at the target end with native-like L2 lexical system and its underlying conceptual meaning system. In describing the L2 learning process and designing teaching syllabus for it, researchers tend to look

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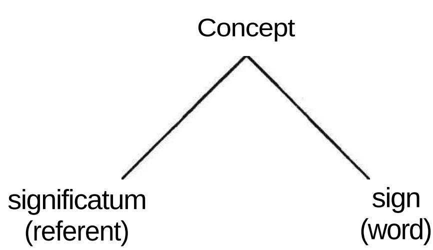
at linguistic and sociolinguistic factors (Rod Ellis, 1986; Breen & Candlin, 1980; Littlewood, 1981; Stern, 1983). But like learning of other subject matters, L2 learning in general and L2 lexical learning in particular has a communication and control aspect. Pask's conversation theory (Pask, 1975, 1976, 1984) can provide a cybernetic systemic perspective to understanding the L2 lexical learning process. The paper has two parts. In Part One, we will discuss three points. First, a lexical system has a formal level and conceptual level, the duality of a lexical system. Second, two lexical systems may differ at both formal and conceptual levels in such a complex way that it defies attempts to map or to systematically describe the differences. We refer to this kind of differences as cross language incongruity. Third, against this cross language incongruity at both formal and conceptual levels, L2 learners use combined strategies of LI transfer and L2 experience-based hypothesis testing to build an L2 lexical system. These three points constitute an L2 lexical learning context in which we, in Part Two, discuss Paskian ideas such as "p" individual participants, self organization and coherence, etc.

## PAET ONE

*Lexical System and Conceptual System*

Philosophers and linguists such as Humboldt, De Saussure, Ogden and Richards have long explained the relationship between language, concept and reality through the well-known triangular diagram, which was first set out by Ogden and Richards (1923). John Lyons (1977) gives a simplified form of the triangular diagram.




These linguists first used this triangular diagram to explain that language is not directly related to reality. Reality has to be first perceived and interpreted by the human mind in terms of conceptual meaning which is then coded into linguistic forms. What is immediately relevant to our discussion is the relationship between conceptual and linguistic systems, namely, linguistic systems which resulted from grammatizing and lexicalizing the conceptual meanings have underlying conceptual systems.

Generally it is very difficult to discuss conceptual and lexical systems separately, as concept formation and lexicalization may be of the same process.

But the following two questions may help us see some cognitive and linguistic characteristics of the relationship between the conceptual system and lexical system. First, is there a difference between the meaning expressed by a lexical item and that expressed with a syntactic construction? Second, why is a conceptual category likely to be lexicalized?

Leech (1981) argues that the word as a lexical element has a concept defining role. He uses the following examples to show the point. Agent nouns such as "driver", "copywriter", and "bed-maker" have in the first stages of adoption a transparent equivalent to relative clauses, so that, for example, "driver" may be defined as "a person who drives", "bed-maker" as "one who makes beds", etc.. But it would be false to claim that the single word and the syntactic construction have exactly the same meaning, for the word carries an additional message, namely, the calling into existence of a category. The word "bed-maker" asserts that there is a special institutional category of persons, whose function or habit is to make beds. Notice the difference, for example, between asking the question *"Is* she a bed-maker?" and the question "Does she make beds?" A person questioned in this way may well reply: "Well, she does make beds, but she is not a bed-maker."

Leech's example argues convincingly that lexical items are of particular importance to a language, and cannot be replaced by syntactic constructions. They are important perhaps because meaning in a lexical item is regarded as a packaged unit and is functionally more needed and therefore more fundamental in the inventory of the language. In other words, lexical items are better defined as conceptual categories. Lexical items reflect both the extent of detail to which we classify a field of experience and the way we classify it. For instance, we know well that the more a field is studied, the more fine-grained the classification will be, because we need more distinct categories to operate with.

But why is a conceptual category likely to be lexicalized? The question can be answered from the linguistic point of view. Some meaning may, at the beginning, be expressed by a syntactic construction such as "persons who write novels". But as soon as a conceptual category has been formed of these persons writing novels (i.e. Novel writing is seen as an institutionalized profession) and consequently there is a frequent need to refer to this group of persons, syntax will not tolerate always allocating them long syntactic constructions such as relative clauses which function as a single semantic unit in the sentence. Syntax will pressurize the prepackaged meaning to lexicalize and appear in the sentence in the form of a single lexical item. In other words, lexicalization is a meaning-chunking mechanism. If languages were not to have such a mechanism of lexicalization, it is hard to imagine how languages could function as they do because we then would have only semantic primitives such as [Human] [Adult] [Male] to operate with and would have to rely excessively on syntactic constructions to express our thoughts.

### *LI and L2 Lexical Systems*

If a lexical system has an underlying conceptual system, what are the implications of this duality to cross language lexical analysis?

Hudson (1989) applied Jackendoffs preference rules (Jackendoff, 1983) in cross language lexical analysis. Briefly, Jackendoffs preference rules revealed that lexical information is organized out of a complex interaction of three conditions: necessity, centrality and typicality. This would imply that people, when learning their LI, learn the cultural-specific criteria for organizing lexical information. For instance, they learn to use a certain ratio between width and height in judging whether a container of certain size can be called "cup". If the ratio between width and height, which is the necessity condition, is deemed inappropriate to call the container "cup", the addition ofa handle to the container, a typicality condition, may help to classify the container as a cup. Furthermore, when sufficient data in the environment are not available for ajudgement, native speakers will rely on the global organization principles in making inferences to supply default values. However, "it seems obvious that the ability of a native speaker to make reference to the culturally appropriate default values may not be shared by L2 speakers in the face of what is an incomplete set of facts. In this light, lexical transfer can be seen as the basing of hypotheses about a word not only on the conditions operant in specific LI equivalents but also on more global Li-based default values." (p. 235) This view emphasizes the cultural experience based criteria for lexical information organization.

Since lexicalization is motivated by conceptual categorization, which is culture specific, LI and L2 lexical systems can differ in many ways. The following list is intended to be illustrative and it is not exhaustive.

- An experience field can be classified to different degrees of specificity (e.g., The number of colour terms varies across languages.)
- An experience field can be classified in different ways (e.g., English and French classify furniture differently, as will be shown below.)
- The internal structure of a lexical item may differ from language to language even though it may be regarded as translation equivalents.
- Metaphorical use ofan equivalent lexical item (e.g., "We hit the road at daybreak.") as opposed to prototypical use,(e.g., "Hit the nail on the head.") may differ from language to language, because different languages may extend and suppress different semantic features of a lexical item.
- As lexical items / concepts exist in a network system, the differences outlined above imply the different organizations of lexical systems across languages.

Let us see some examples of the differences between lexical systems outlined above.

*Difference in the level of specificity of classification.* Kinship systems of English and Chinese share many similarities but there are also quite many differences. For example, in English, there is only one word denoting children of parents' siblings, namely, "cousin". In other words, children of parents' siblings do not constitute a semantic field in English. "Cousin" is a member of the semantic field of kinship. From the viewpoint of the Chinese culture, the term is too general to be functionally adequate. In Chinese, a cousin's sex, whether younger or older than oneself, has to be specified as part of semantic features in a lexical item. Thus we have:

| | |
|---|---|
| *tangxiong* | (father's brother's son, older than oneself) |
| *tang di* | (father's brother's son, younger than oneself) |
| *tangjie* | (father's brother's daughter, older than oneself) |
| *tang mei* | (father's brother's daughter, younger than oneself) |
| *biao xiong* | (father's sister's son or mother's brother's or sister's son, older than oneself) |
| *biao di* | (father's sister's son or mother's brother's or sister's son, younger than oneself) |
| *biaojie* | (father's sister's daughter or mother's brother's or sister's daughter, older than oneself) |
| *biao mei* | (father's sister's daughter or mother's brother's or sister's daughter, younger than oneself) |

We can observe certain characteristics in this system of classification. 1) Children of parents' siblings constitute a sub-semantic field in the field of kinship. 2) The levels of specificity of "tang" and "biao" are different. "Tang" is more specified than "biao". Note that the distinction between "tang" and "biao" is not determined by whether the cousin is of one's father's side or mother's side, but by whether the relation between the speaker and the cousin has crossed the sex line in one's parent generation. One's relation with father's brother's children, all denoted by the morpheme "tang", has not crossed the sex line in one's parent generation and they all bear the same family name as oneself. The relation between oneself and the rest of the cousins, all denoted by the morpheme *"biao"*, has crossed the sex line. These cousins do not have the same family name as oneself. This system of classification clearly reflects aspects of the Chinese culture, specifically the view of family, which we do not have space to look into here.

*Difference in semantic components of translation equiualents.* The boundaries between the meanings of what at first sight appear to be semantically equivalent words in different languages may be incongruent. To show the point being made here, John Lyons (1977) analyses translating into French the sentence "The cat sat on the mat". We first come to the problem of translating the English word "cat". Should we put it as "le chat", knowing that the animal being referred to was male or being ignorant of and unconcerned with its sex? Or as "la chatte" knowing that it was female? 'The fact that French will use ~chatte' in reference to a female cat, known to be female, whereas English will not necessarily use a phrase like "tabby cat' in the same circumstances means that "cat' and ~chat' are denotationally non-equivalent." The translation of "the mat" is more interesting. "The mat" is translatable into a number of distinct, nonsynonymous French lexemes: "paillasson" (a door-mat); "descente de lit" (a bedside mat); or "tapis" (a small rug). "There is a set of lexemes in English, "mat*, "rug", 'carpet', etc. and a set of lexemes in French, "tapis', "paillasson', "carpette', etc., and none of the French words has the same denotation as any one of the English lexemes. Each set of lexemes divides, or categorizes, a certain part of the universe of domestic furnishings in a different way; and the two systems of categorization are incommensurate." (p. 238) In other words, each language divides up the semantic space of a particular field in its own way, and the denotation of a lexeme is limited by the relations of sense which hold between it and other lexemes in the same language. The denotation of "mat" is limited by its contrast in sense with "rug" and "carpet"; the denotation of "paillasson" in French is limited by its contrast in sense with "tapis" and other lexemes. Therefore the meanings of words are internal to the language to which they belong.

*L2 Lexical Learning*

We can now look into some details at how a learner, in the process of learning L2 vocabulary, constructs an L2 lexical system, at both the formal level and the level of substance. But before that, let us take a brief look at Clark's (1973) and Nelson's (1974) studies on children learning LI words. Both of these studies are valuable to language acquisition research in their view that children do not learn a word overnight. A child does not either know or not know a word. Rather, there is a process of learning a word, as a word is meaningful to him/her only so far as the child perceives and conceptualizes certain experience that the word has lexicalized. In other words, at a certain stage, the child may be able to use a word for part of its meaning, but s/he has not acquired the word to the full extent. S/he may even have to readjust the perceived semantic distinctions of the word. For instance, the child may call both an apple and a ball "ball" because the semantic distinction s/he has perceived is [Round]. So at a certain time, s/he will disassociate "apple" from "ball" while continues to expand his/her perception of other semantic features of the word. For instance, apart from [Round], "ball" has other features such as [Bounce]. Later on, the child has to learn sense relations between words (e.g., the relation between "parent" and "child"), and construct a hierarchical order of words (e.g. Flower and trees are plants.) What we see here is that a child's lexical development is closely related to his/her conceptual, cognitive development.

An adult L2 learner probably does not have a cognitive maturity issue. And it is controversial whether the L2 learner acquires the L2 conceptual system separate from the LI conceptual system. How do we describe the process of an adult L2 learner learning L2 vocabulary? Selinker (1972) proposes the notion of interlanguage. An interlanguage has three basic characteristics: 1) at any given stage the learner's language is a rule-governed system; 2) the system is permeable as it evolves toward the target language; and 3) the learner's language may fossilize at a certain stage and the learner falls short of acquiringa native-like L2 system. The interlanguage theory is one of the ways to describe the learner's evolving L2. We would suggest that L2 learners learn L2 vocabulary in a way similar to LI children learning words of their mother tongue, with one important difference. That is, when an LI child has not perceived and conceptualized certain semantic features of a lexical item, or relations between lexical items, s/he is, to that extent, cognitively and expressively restricted. But an adult L2 learner is likely to understand L2 lexical items from the perspectives of his/her LI, as pointed out by Hudson (1989).

The learner's interlanguage lexicon at any stage is different from those of LI and L2. S/he may, on the one hand, transfer LI meanings to L2 lexical forms, (using a deductive process in applying LI global organization principles) and, on the other hand, acquire L2 cultural experience-based information of the lexical item, (using an inductive process) to form hypotheses on L2 lexical items (Hudson, 1989). So the learner's lexicon has a system of its own and with its own variations. Transfer of LI lexical meanings in order to understand L2 words is facilitative to L2 acquisition but may also inhibit a native-like mastery of an L2 lexical item.

## PART TWO

*Conversation Theory*

From our analysis above, we see that the duality of lexical system, cross language incongruity, and learners' combined strategies of LI transfer and L2 experienced-based hypothesis forming make L2 lexical learning a complex, dynamic and ever evolving process. An adequate description of such a process requires a cybernetic dimension which conversation theory can provide. Given the limited space, we can here only attempt a short summary on the two fundamental issues of conversation theory.

*What Learns ?* The commonsense answer: that individuals learn, is probably a most misleading answer. Integrated whole-self learning is the rare ach ievement of only very mature individuals (Boyd & Myers,1988), while learning by semi-autonomous parts of persons, or by distributed assemblages of parts [intra-body and trans-body *"p'* individuals (Strawson, 1959; Pask, 1975; & Boyd, 1991)], are the usual kinds of learning. Actually, the answer to the question: WHAT LEARNS? appears to be a dual or triple one: both parts of people, and networks of parts of people associating in groups do learn, as well as indeed, but more rarely whole integrated "Selves'.

Conversation Theory postulates that we have prototypical autopoietic virtual organisms in our minds/Central Nervous Systems (CNS) which develop into viable participant individuals "V individuals" through external and internal learning/teaching 'conversations', 'p' individuals do not correspond directly to biological individuals. Each biological individual carries many intra-body **p'* individuals (both personae, and dynamic conceptual complexes), and also carries parts of some distributed or trans-body 'p' individuals (such as: languages, religions, ideologies, team-spirit, etc.) Current work in cognitive science

(Martindale, 1991) and neurophysiology indicates that different kinds of learning *occur* in different parts of the CNS and that the various kinds of memories associated with a particular episode are somehow "bound" together by as yet undefined mechanisms. We are inclined to interpret 'p' individuals, or what we prefer to call AVOs (Autopoietic Virtual Organisms), as the "binding[1] agents — whatever they may actually be physiologically.

*How Do "p'Individuals Learn?* Paskian conversation theory asserts that: If the conversations are related to an objective domain and are devoted to the elaboration, comparison, and correction of conceptual entailment meshes representing that domain, then valid knowledge will be constructed, will be bound together, will be remembered, and probably will be transferred as needed for the viability of the 'p' individuals.

There are similarities with George Kelly's "Personal Scientist" theory. However, binary categorization has no special importance for conversation theory. Harri-Augstein and Thomas's learning conversation methodology (1991) sort of combines Kelly's theory and Pask's theory, but practically, rather than with any formal rigour. There are similarities with Scandura's structural learning theory, but Scandura does not posit 'p' individuals. Since entailment meshes are flexibly hetrarchical, not intrinsically hierarchical, Gagne's hierarchical learning & instructional theory is a sort of degenerate case of conversation theory (again without 'p' individuals).

*Participants*

*A* participant is "a system of concepts that is organizationally closed, informationally open, and self-organizing" (Pask, 1984 p. 12). The value of this definition seems to be twofold. One is that a '/p' individual is an organizationally closed system, able to maintain its integrity and distinctiveness. But it is informationally open. It accepts information that coheres with it and rejects information that does not cohere with it. Thus, the system can grow while maintaining its distinctiveness or identity.

The other advantage of this definition is that it transcends the biological boundary of persons. It thus accommodates a system of concepts residing in a computer or a human group. The definition captures a very important insight in that we can regard a particular system of concepts residing in a student as participant A and a similar system residing in the public as participant B. Thus, a student can go to professor Smith's lecture, read Professor Brown's book or use computer-aided instruction. The relevant system residing in the lecture, the book and the computer-aided instruction is Participant B. Through interaction with this Participant B, Participant A residing in the student grows and refines itself.

A further property of'p' individual is self-organizing, a notion which we will discuss later.

In the literature of second language acquisition, the minimum unit participant is implicitly taken to be a person, although a person is looked at from different perspectives such as his/her cognitive style, socio-economic environment etc. Pask's definition of participant would enable us to focus on the acquisition of particular systems of L2. For example, a learner's English tense system, his/her conceptual organization of L2 kinship, and even his/her use of a particular set of semantically related L2 lexical items can be viewed as participants. The concepts in these systems are the personal concepts and they will, through interaction in the task domain, evolve toward the public concepts residing in L2 native speakers and their language productions.

*Self Organization*

Self organization is manifested when a person in a task context executes the task efficiently, adaptively and with relevance to what is going on around him/her (Harri-Augstein and Thomas, 1991). Self organization thus contrasts with ritualized execution of a task in which a person performs a task in a robot-like manner.

What does it mean by 'p' individual being capable of self organization? It means the 'p' individual in a task context must set up a feedback loop with the environment and carry a conversation with itself. The feedback loop is needed for it to assess the environment, set intermediate goals and formulate concepts, rules and strategies to guide its interaction. Then as the learner interacts with the environment, it must constantly assess the effects of the interaction in relation to its goals and evaluate the mental model which guides the interaction. During this process, the 'p' individual carries on a conversation with itself in constructing and revising the mental models alongside the progression of the task. Learning occurs as successively revised mental models enable it to approach ever closer to thesuccessful completion of the task, because its mental models now approximate more closely than before to what is in the environment.

This aspect of self organization is in agreement with Simon's view of learning that our cognitive complexity is due to the complexity of the environment and is acquired through our interaction with the environment (Simon, 1981).

In L2 acquisition literature, the communicative approach (Littlewood, 1981, 1984; Ellis, 1986, 1990; Stern, 1983; Canale & Swain, 1980) and under its umbrella, the tasked-based syllabus (Breen & Candlin, 1980; Breen, 1987a, 1987b, 1987c; Candlin, 1984; Foley, 1991; Nunan, 1989) are based largely on semantic and sociolinguistic considerations, namely, that learners should focus their attention on the meaning in communication rather than on linguistic forms. Few researchers are aware that the strength of the task-based syllabus may be also due to the fact that it utilizes the notion of self organization. Self organization in an L2 learning task context has two important aspects. First, it brings out the control and communication aspect of L2 lexical learning to which little attention has been given so far. Second, it raises the issue of designing optimal tasks in relation to learner sophistication.

By definition, if a *'p'* individual executes procedures of language processing with complete automaticity while performing a task, s/he is not self organizing in terms of language learning. In other words, s/he has to have some challenge in constructingand executing procedures of language processing in order to activate self organization. Only when the learner is self organizing in a task context, can the task become both a source of L2 lexical information and a medium.

When participant A in an L2 learner is self organizing in a task context, it is open to the information coming out of the complex interaction of three L2 lexical organization conditions: necessity, centrality and typicality and to the global organization principles in default of sufficient information, of which Hudson (1989) speaks. This experience based information gained through interaction with participant B in L2 culture is the basis on which L2 lexical hypotheses are formed and tested. It is the foundation of the whole L2 lexical system. And in case of disagreement, it will override any information transferred from LI equivalents.

Task as a medium enables the learner to set up a feedback loop with the environment. The learner thus can assess the effect of language use in relation to task progression. For instance, correct use leads to successful communication which in turn leads to task progress. Incorrect use results in unsuccessful communication (confusion or misunderstanding) which leads to no task progress. With the feedback loop, the learner is engaged in conversation with him/herself, perceiving needs, looking for solutions, acting upon hypothesis, reflecting on the effect of the action and revising the hypothesis. The learner is thus self organizing in the task context. The task provides an environment for this process. But the process will only occur on the condition that the learner be self organizing.

The second aspect of the notion concerns the complexity of the task as opposed to learner sophistication. Two extreme cases would ensue if one set of variables (either task complexity or learner sophistication) is held constant while the other grows in complexity. If the variation of the task environment is fixed at a manageable level, while the variation of the learner increases as s/he acquires correct rules and concepts, the learner will soon adapt to the environment. On the other hand, if the variation of the task environment increases while the variation of the learner remains constant, the learner will quickly find that his/her hope of successful performance is disappearing.

The notion of self organization has raised an issue of optimalization. How can we arrange the task environment in such a way that the learner's self organization is optimally utilized? Optimalization is an issue that has consequences not only in learning efficiency but also in motivation, for both boredom from the lack of challenge and despair from the lack of hope of success tend to destroy motivation.

Optimalization concerns the ratio of change in the complexify of task to the change in learner sophistication. To achieve the optimal utilization of self organization by arranging appropriate task environments, the following topics have to be researched:

- What are the variables that constitute task complexity?
- What are the variables that constitute learner sophistication? (For a discussion of task complexity and learner sophistication variables, see Nunan, 1989 pp.96-116.)

- What relationships exist among these variables?
- What is the optimal rate of change in the values of the variables in the task environment as opposed to the rate of change in the values of the learner sophistication variables?

Furthermore, these research topics concern only optimal utilization of self organization, an efficiency issue. There is also an effectiveness issue of what kind of tasks for developing a particular competence.

*L2 Learners in Conversation*

We have defined participants and discussed self organization in a task environment. Now let us see how an L2 participant actually engages in a conversation through which an early interlanguage lexicalsystem evolves toward the L2 lexical system.

Information transfer can occur at two channels: within-participant channel and between-participants channel. In L2 lexical learning, within-participant information transfer deals with the problem of achieving automaticity of an L2 item. The between-participant information transfer describes the process of acquiring the conceptual meaning of an L2 item. In this section, we will discuss the between-participant information transfer and leave the within-participant information transfer to the discussion of coherence.

In the between-participant information transfer, participant A is a subsystem of L2 residing in a learner. Participant *B* is a subsystem of L2, not necessarily biologically bound. In an *A-B* interaction, *A* displays, in the task domain, the personal concept or hypothesis of a certain item which could be a lexical item in L2 form but with elements of equivalent LI meaning or usage. *B* displays its uses of the same item. A lack of agreement between *A* and *B* may be perceived by both *A* and *B, if B* resides in a tutor or native speaker. Here we have an issue of communication threshold. If the disagreement between *A* and *B* over the item is severe, communication breaks down, resulting in confusion and misunderstanding. The situation has to be rectified quickly. *A* tries to build a mental model of *B's* understanding or usage of the item in order to revise his/her own, so s/he can understand *B's* use of the item and be understood. *B* tries to build a model of *A's* understanding or usage in order to identify the confusion and misunderstanding, or help A. A now is also engaged in a conversation with him/herself, for s/he has used an item and has perceived the effects of the use through the feedback loop. The assessment of the effects indicates that his/her hypothesis of the item needs to be changed. *A* is thus self organizing. In fact, *B* is also self organizing. However, the benefits for *B* is not language learning, but the progression of communication and perhaps learning something about tutoring an L2 learner. *A* and *B* are thus mutually adaptive.

Let us see a concrete example of *A-B* interaction. If a Chinese learner of English initially understands "catch" through LI transfer, s/he finds agreement with an English speaker in using "catch a bird", "catch a ball", "catch a thief, etc.. However, when the Chinese learner says "catch something firmly", as his/her LI equivalent has this usage, there is a disagreement between A and *B*. *B* never uses "catch" here but "hold" or "grasp." A makes an adjustment. On the other hand, *B* also uses "catch a cold", "catch a bus", which A never uses in LI for the translation equivalent of "catch". A acquires these uses. Now as the interaction goes on, A builds a model of B's understanding of the word "catch" in order to learn. *B* also builds a model of A's understanding of the word "catch" in order to teach.

The important thing, of course, is not that A has correctly suppressed a usage of "catch" transferred from LI, and successfully acquired two correct usages. What is important is that s/he can now see the connection, in his/her conceptual system, of the uses of "catch" in all the contexts in which the word is used, and derive from these uses a more accurate meaning of the item.

Here again, we have come to the issue of devising appropriate tasks for instructional design. Communication threshold serves as a go or no-go communication traffic light. However, this threshold is generally easy to surmount. Languages have built-in redundancies (e.g., Words in a sentence can explain and predict each other). Contextual clues help prevent communication from a total breakdown even if participant A's use of an item is not in agreement with B's. Furthermore, a specific task may not exact a high level of accuracy in communication. If the task based syllabus hopes to enable learners to attain a high L2 competence (both fluency and accuracy) by utilizing self organization in task context, it has to be able to fine tune the tasks so as to raise the communication threshold to present increasingly greater challenges to learners.

Some of the techniques for fine tuning the tasks may actually include the reduction of language redundancies and removal of some contextual clues in addition to devising tasks which require higher accuracy of language use. Complementary to successively fine tuning the tasks is to motivate and enable the learner to acquire some sensitivity and conscious control over his/her learning, so that even if a communication task is accomplished with less than perfect L2 use, the learner will reflect on his/her L2 system and revise part of it to move it closer to the target L2 system.

*Coherence*

Coherence is a desired result of conversations. Pask (1984) speaks of coherence at three levels. Firstly, there is the coherence of procedures that make up a particular personal concept and coherence between new procedures a personal concept produces and other existing concepts (p.9). Secondly, there is the coherence, also called agreement between participants A and B. The process of achieving type two coherence was described in the preceding section. Thirdly, there is coherence of concepts in a mental organization. In L2 lexical acquisition, type three coherence refers to the coherence at the level of a subsystem such as the entire L2 lexicon or grammar and at the level of the L2 system. A language item, whether a grammatical category or a lexical item, exists in a network system. This fact entails that an L2 learner needs to achieve agreement not only at the level of individual items, but also at the level of the whole subsystems. However, how this level of coherence is achieved is unknown. Here we will concentrate on type one coherence. Type one coherence in L2 learning is automaticity achieved through the within-participant information transfer, which is defined by Pask in terms of awareness within a participant. "So, as you learn, there is a stage of awareness of 'how to do things', even though you may not be proficient at doing it. As conceptual proficiency increases, so you are increasingly aware of what to do, but find it hard to answer a 'how question'. Later still, a concept is applied automatically and, as a rule, proficiently. There is no internal information transfer, unless various kinds of disturbances take place." (Pask 1984, p. 11)

Is this type of information transfer and coherence applicable to L2 lexical learning? The answer seems to depend on whether L2 learners using communicative approach are conscious of the linguistic rules being acquired. Unfortunately, this is still an unsolved issue in L2 research (Chaudron 1988, pp. 6-7). We believe that learners vary in degree of their awareness of their actually constructing and applying "algorithms" when first using an L2 lexical item or a grammatical item. In a sense, it does not matter here whether they are aware of the process of constructing and applying the procedures. What matters is the fact that the execution of the procedures when trying for the first time to use an item takes longer time and takes up more attention space than if the item is familiar to the learner. The longer time and more attention space are needed for the internal information transfer.

Ideally, automaticity should occur alongside the evolution of the interlanguage item toward the target L2 item. Both of these processes occur in a self organized learning in a task environment. The application of an item by executing a set of procedures in the task domain produces a new set of executable procedures. In other words, to the learner, each application of the lexical item in a new context is a hypothesis test, which may well result in a set of revised procedures or new procedures.

Before automaticity is fully achieved, the information transfer via the feedback loop is still open. The learner is in conversation with him/herself in assessing the meaning of the item in each new context and in hypothesizing the criteria of L2 lexical information organization. Thus, the applications of an item, on the one hand, helps to move the learner's conceptual understanding of the item closer to that of native speakers'. On the other hand, each application of the item in the task domain makes the procedures more coherent and when a sufficient range of contexts in which the item is used has been familiarized and no new procedures are produced through applications, no internal information transfer between the precept of the concept and application of it is needed. The execution becomes more automatic.

*Fossilization*

All the three types of coherence are very desirable in L2 learning. Here L2 learning differs from the learning of other subjects such as sciences. In learning a science, cognitive growth is in terms of cognitive complexity. Pask's type three coherence and its subsequent conflict with the need to maintain identity and distinctiveness of concepts captures the insights that cognitive growth proceeds by concept cohering and splitting, an apparently paradoxical process. Coherence and no information transfer could mean intellectual stagnation. In L2 learning, cognitive growth is in terms of conducting cognitive activities in another conceptual/linguistic system. All the three types of coherence are ends in themselves. However, it is crucial to keep automaticity from setting in before type two and three coherences attained the desired level.

In terms of conversation theory, fossilization can be defined as coherence of type one without coherences of type two and three. That is, the learner gets into the automatic execution of procedures and stops being self-organizing. Unfortunately, such automaticity often occurs before the learner's personal concept has successfully evolved to the target L2 concept and before the learner's interlanguage subsystems and system have evolved to the L2 subsystems and system. Thus, a learner may speak L2 with a foreign accent all his/her life, use LI structure all the time (e.g., "He has been here since three years), and use LI lexical meaning (e.g., *Close* the light, please).

The solution to fossilization is of great interest to instructional design in L2 learning. According to our analysis of fossilization, the solution seems to lie in introducing disturbances with the aim to make the learner alert about his/her uses of an item. In other words, ways must be found to help the learner set up the feedback loop again for information transfer between the conceptual understanding and execution procedures in the task domain, so that the learner will once again perceive disagreement between his/her uses and participant B's uses of the item and revise his/her understanding.

The disturbances are generally in the forms of new challenges or difficulties which halt the automatic execution of procedures and force the learner to re-examine his/her understanding and uses of the item. Ironically, redundancy in language and contextual clues, which facilitate communication, present some difficulties for designing ways to alert the learner. For example, short of explicitly pointing to the learner that his/her use of "close" in "Close the light, please" is in disagreement with the L2 lexical system, how do we design tasks that raise the communication threshold to block the communication because of this use of "close'? In most cases, when the communication threshold does not catch an interlanguage item by blocking the communication, the natural mechanisms in the learning environment, which set the learner to be self-organizing, cease to function.

In a situation like this, some recourse must be found to continue to move the interlanguage item toward the target L2 item. One is the explicit pointing to the item to the learner by a teacher or tutor. This is error correction. Chaudron (1988) reviewed empirical studies on error correction in L2 classroom and concluded that error correction does not constitute a major proportion of the activity in L2 classroom which focuses on communicative activities and that it is a great error to assume that what occurs as "correction" in classroom interaction automatically leads to learning on the part of the student (pp. 134-153).

If customary error correction consists of simply pointing out the error and providing the correct use of a word or correct word for a situation, lack of effectiveness is perhaps due to two causes. First, this is a simplistic approach. As we have seen, the meaning of a language item is culture-based. A key factor in acquisition of the item is experiencing the culture, on the basis of which the learner learns criteria of lexical information organization and the principles for making inferences in cases of incomplete data for a judgement. Conversational error correction works largely at the level of linguistic forms instead of culture experiencing. Secondly, since the acquisition of the meaning of an L2 item requires experiencing relevant L2 culture and experiencing has its own rate of progression, which is still largely unknown, the learner has an "internal syllabus". This explains why the learner may readily learn some items but not others despite repeated corrections. Error correction basically ignores this learner readiness factor.

However, error correction has its usefulness as a complementary approach. First of all, it calls the learner's attention to his/her use of an item and may make him/her notice the disagreement, which, otherwise, may never come to his/her attention. Secondly, when left alone to figureout the meaning of an L2 lexical item and its usage entirely on his/her own, the learner generally needs more time to form, test and reform the hypotheses before s/he finally gets the L2 conceptual understanding and usage of an item. Some learners may never get it. Thirdly, error correction as a recourse supplementary to communication focused activities can overcome the problems mentioned above, if the task context in which the learner is self organizing provides ample opportunities for L2 culture experience.

The implication of this analysis is that when task based syllabus could not be provided or when it becomes too expensive to design the task environment at a high fine tuning level in order to continue to utilize learner's self organization, instructional design should consider other recourses as complementary approaches.

## CONCLUSION

A semantic and cognitive analysis reveals that L2 lexical acquisition must have an L2 cultural experience base. The best environment for such a base to form is an L2 task context. However, the task context has to be arranged in such a way that the relevant participant residing in the learner is self organizing. Only when self organization is activated, can the task becomes an effective source of L2 lexical information.

Effective and optimal utilization of self organization of ~p' individuals presents a great challenge to task-based syllabus and L2 instruction design in general. The learner must be self organizing and yet must not be overwhelmed by the task complexity. Furthermore, we have yet to find a way to prevent automaticity from setting in before desired level of type two and type three coherences is achieved. Finally, task-based syllabus can be profitably complemented by more linguistic form oriented approaches such as error correction.

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# Technology Education for Democracy

William J. Egnatoff

**Abstract:** Educators use new technologies to support creative expression, to increase literacy, to address special learning needs, to develop students' problem solving skills, and to prepare youth for adult life. Yet, to cultivate democracy, educators should ask whether what they do with computers and other electronic media in education: 1) promotes justice; 2) restores reciprocity; 3) confers divisible or indivisible benefits; 4) favors people over machines; 5) minimizes long-term disaster or maximizes short-term gain; 6) favors conservation over waste; and 7) favors the reversible over the irreversible (Franklin, 1990, p. 126). Favorable answers lie in examples of the use of technology in classroom practice in which: curriculum is based on student themes, learning is socially mediated, traditional discipline boundaries are crossed, teachers and students collaborate on projects and case-studies, and students learn the cultural and political significance of what and how they learn. Technology education for democracy is based on the participation of students and teachers in adapting technology holistically to shape classroom reality.

**Resume:** Les educateurs utilisent les nouvelles technologies pour encourager ('expression creatrice, favoriser I'alphabetisation, repondre a des besoins particuliers d 'apprentissage, elaborer des strategies de resolution des problemes et preparer les jeunes a la vie adulte. Pourtant, afin de promouvoir la democratie, les educateurs devraient se demander si I'utllisation des ordinateurs et des autres medias electroniques en education : promulgue la justice; retablit la reciprocite; accorde des benefices divisibles ou indivisibles; favorise la personne plutot que la machine; minimise les desastres d long terme ou maximise ies gains a court terme; favorise la conservation plutot que le gaspillage; et favorise le reversible plutot que I'irreversible (Franklin, 1990, p. 126). On obtient des reponses affirmatives d ces questions quand le programme d'etudes est axe sur les themes qui touchent les etudiants, quand I'apprentissage passe par la mediation soclale, quand les limites des matieres tradltionnelles sont depassees, quand les projets et les dossiers sont abordes en collaboration avec les etudiants par les enseignants et enfin, quand les etudiants prennent conscience du sens culturel et politique de la matiere et des methodes d'apprentissage. Pour qu'ii y ait democratie, les etudiants et les enseignantsdoivent modeler la realite dessalles declasse en abordantd'unefaeon holistique I'enseignement des nouvelles technologies.

> As a community we should look at what the new technologies of message-forming and -transmitting do to our own real world of technology and democracy.
>
> *Ursula Franklin*

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## INTRODUCTION

The health of democracy depends upon individual, local initiative that shapes political and cultural reality. To preserve democracy and to cultivate cultural richness and diversity, teachers have an important role to play in encouraging student initiative. The methods teachers use, including the application of new information technologies, carry important messages to pupils about the nature of society and their place in it. Technology can be used to direct students' learning or to empower them to direct their own learning. Working with students to adapt technology to support initiative in the classroom is education for participatory democracy, education designed to give students a moral advantage.

This paper provides a framework for examining classroom practice to see how technology is being used to support democratic participation. In this framework, technology is construed broadly as systematic practice and technology education is construed as the weaving of technology into the fabric of the curriculum. Six diverse examples illustrate how various image- and message-forming technologies may be used alongside older technologies to support a holistic curriculum. The framework is based upon ideas articulated recently by Franklin (1990).

We live in a technologically dominated world, a world governed largely by systematic practice characterized by "organization, procedures, symbols, new words, equations, and most of all, a mindset" (Franklin, 1990, p. 12) centred primarily on short-term consumer-driven goals of production and only secondarily on holistic, long-term concern for sustainable growth in a global community. With our minds set on technological detail supporting a comfortable life today, we often act in conflict with human and democratic values that underlie our vision of tomorrow. Thinking critically about examples close at hand is a good way to address the conflict between a production-oriented prescriptive mindset and a growth-oriented holistic mindset.

In her published addresses on the real world of technology, Ursula Franklin chose examples through which to examine critical questions about human endeavor. A deep concern for justice underlies her analysis:

> Central to any new order that can shape and direct technology and human destiny will be a renewed emphasis on the concept of justice. The viability of technology, like democracy, depends in the end on the practice of justice and on the enforcement of limits to power. (1990, p. 14)

The use of message-forming and -transmitting technologies can impede justice and concentrate power by reducing reciprocity in communication. To maintain a modicum of reciprocity in predominantly one-way media, newspapers publish letters to the editor, radio stations have phone-in shows, and local television stations give some air time to local spokespersons. The telephone lends itself well to reciprocal communication, communication in which power and influence is shared. Electronic mail and electronic conferences allow reciprocal communication among small groups with common interests. It is not the media themselves that lead to reciprocity but the systematic use of the media, the technology of media control.

An important measure of justice in technologically driven enterprise is the extent to which everyone benefits. Government effort that ought to be directed primarily towards indivisible benefits for all — clean air and water, education, health — is instead diverted towards the infrastructure supporting the private sector. Public funds spent on transportation and communication systems and government policy on tarifs and trade favor private interests with loud voices. Individual citizens, those most directly affected by large-scale enterprise, need to understand the technology of reciprocal communication in order that they may give voice to their concerns.

Prescriptive technologies, designed for profit and efficiency, favor *machines over people*. For example, in the early days of the telephone, women who served as telephone operators in small communities, knew the people and daily events. They wove channels of communication that maintained reciprocal communication among citizens. Now their work has been largely replaced by automated switching networks that provide rapid one-to-one links but which have no other role in building community. Automation often reduces the control and commitment of individual workers. The same can be said about curriculum technology in which learners and even teachers feel they have little say about content and methods.

In some large-scale endeavors, affected voices are heard. In the Berger inquiry into the proposed Mackenzie Valley pipeline, authorities listened to those who would be most affected, and sought alternatives designed not to maximize gain but to minimize disaster, to favor conservation over waste, and to favor the reversible over the irreversible. Is public education responding in the same way to Franklin's concern for viable technology in a viable democracy?

In Canadian education, the public expresses its values formally through goals published by provincial ministries of education, goals indicating that teachers should develop in students practical knowledge, resourcefulness, adaptability, creativity, a feeling of self-worth, self-reliance, esteem for others, respect for the environment, and "a sense of personal responsibility in society at the local, national and international level" (Ontario Ministry of Education, 1983, pp. 6-7). More specifically, students taking computer studies courses in Ontario are expected to learn to:

> appreciate the specific benefits and possible problems that have resulted, particularly in Canada, from technological achievement; and to
>
> • evaluate their own attitudes and values as these relate to the possible uses and abuses of computer technology in society. (Ontario Ministry of Education, 1983, p. 7)

How is public education organized to attain such goals and objectives?

Canadian educators have a technological mindset towards curriculum. The path of curriculum development and implementation proceeds from legislation to ministerial goal setting to preparation of curriculum documents to school board program planning to school course offerings to realization in the classroom. Whatever goals, policies, and directives may be set for teachers, what counts in the final analysis is what teachers actually do. This paper therefore presents particular examples of how dedicated teachers, caught up in daily routines of lessons and evaluation, work in and around existing structures to prepare their students well for participatory democracy.

Students should not be led to think that democracy is a given, nor that the form of democracy we have today is unchanging or unchangeable. They should come to understand that the new technologies of message-forming and -transmitting have become a vital part of the political infrastructure that supports the technological infrastructure. They should come to understand that new technology makes possible new twists to democracy — new means of control and new means of fuller participation; new and tighter hierarchies; new opportunities for destroying the social fabric or for changing its texture, weaving a strong flexible, dynamic web of participation. Certainly, student government and social studies courses contribute to preparation for democracy, but so does participation in shaping the social dynamics of the classroom and in shaping the nature and content of the curriculum. The examples that follow illustrate how various technologies, new and old, have been woven into classroom life to support student participation and student initiative.

## EXAMPLES

*Example 1. Children as Composers*

It is quite common for children to see themselves as authors and artists, but less common for them to see themselves as composers. Children do make their own music and musical instruments, and some even invent their own notation, but rarely are children encouraged in school to compose. This simply is a matter of the expectations and environment that parents and teachers create at home and at school. One of the author's colleagues addresses this problem in her own teaching and research (Upitis, 1990). The technology used in her integrated arts-based education is readily available: selected junk to make musical instruments (elastics and string, plastic straws, pop bottles and their caps, water, copper and plastic pipe), and the usual sorts of art materials for developing notational systems and for related art work. Computers and MIDI-based synthesizers are used to increase opportunities for improvisation leading to composition, and to publish records of students' creative work. In this environment, students naturally take a supportive interest in one another's work and come to see composition as a contemporary activity. How different that is from the common habit of purchasing music to listen to rather than creating it; consumer folk art has displaced participatory folk art.

If Canadian adults had had more experience in diverse forms of artistic expression throughout their schooling, they would raise their voices to ensure higher levels of support both for local artistic endeavor and for internationally admired Canadian cultural institutions such as the National Film Board, the Canadian Broadcasting Corporation, and the Canada Council. The public would invest more in enterprises that provide indivisible benefits, strengthening Canada's identity and increasing its cultural richness.

Through the example of integrated arts-based education, the author makes a special plea for the elevation of the artistic and spiritual (which are inseparable). For the good health of democracy, people must regain their mythical roots and a mystical perspective. If people approached more of their living artistically, they would not see science as a preferred path to knowledge and prescriptive technology as a preferred means of action. Through drama, poetry, art, and music, in all their modern, technologically supported and scientifically studied variants, children learn how better to understand and to love themselves and others.

*Example 2. Using Computers to Build Self-Confidence*

> The classroom atmosphere is the biggest contributor to building confidence...Computers add a vibrancy to the room. Pupils feel good about themselves and they respect each other as equals. The high interest that develops from working on a computer promotes a sense of worth and a desire to learn. (Blair, 1987, p. 34)

A teacher of a split Grade 7 and 8 class inherited a plethora of personal and social problems — inflated or deflated egos, self-destructiveness, disruptiveness, abrasiveness and rebelliousness, ridicule, racial discrimination, cruelty. She deliberately chose to use the one computer in her class in ways which she felt would enhance the self-image of her pupils. She recognized quickly that they did not want the computer to be held over them as a carrot, but wanted to help each other use it. That was her key. Changes in attitude and behavior were not immediate, but they were clear and lasting.

For each pupil needing special attention, the teacher found a suitable approach. A disruptive, ridiculed bully was allowed to work on his own at programming. Gradually he became a respected expert. A self-destructive child spent many happy hours at the computer tutoring and befriending younger pupils. His work habits improved and the way was paved for an improved relationship with his peers. Another pupil with a huge ego learned patience and gained respect also through tutoring of younger children; he then was able to tutor his peers. The teacher set him to work on a computerized adventure game in collaboration with an underachiever, who gained an unlikely friend and also came to take an interest in the teacher as a person. A bright, abrasive, rebellious pupil began to see herself for what she was through reflection on her interaction with acomputerized board game and with a quiet pupil with whom she was paired. She began to focus on mastering the game and was then able to patiently teach her classmates, who consequently saw her in a different light. A shy pupil who had failed a grade was always competing with his know-it-all cousin. The teacher sought his technical computer expertise, which led to a more cheerful disposition, respect, and openness. He even became a conciliator in disputes between teacher and other pupils. The teacher used an interactive story-writing program to dissolve a strong clique of four girls. Having to seek the opinions of peers on options at each branch point in the story led to increased cooperation and respect for the opinions of others. Similarly, when teacher-selected groups shared clues and maps in a problem-solving adventure game, unexpected friendships emerged. In each case, the teacher found engaging activities that made her pupils see themselves and their peers in a better light.

The teacher favored people over machines, and healthy personal and social growth over computer literacy. Had her priorities been reversed, the personal and social problems in her class would have stood as obstacles to teaching. Instead she chose to address directly the human curriculum of love for self and others. Individual expertise became something worth having, sharing, and tapping. Students came to teach each other in an atmosphere of caring, interest, and cooperation. The teacher developed a holistic curriculum technology, a technology supporting the growth of a caring community of learners. She adapted her teaching to individual needs and daily exigencies.

*Example 3. Designing Software for a Sexuality Fair*

Human sexuality is a central part of the real adolescent curriculum, yet do teachers and parents discuss it openly and do students have a role in shaping the sexuality curriculum? A remarkable example arose in the fall of 1989 in a Grade 11 computing course at a high school in a small city in eastern Ontario. In preparation for a school-wide spring fair on sexuality, a family planning counsellor presented the computer science teacher with four interactive scenarios that she asked his class to translate into computer programs. (This was but one way she sought to involve students from many subject areas.) Accepting the challenge, his class changed the whole focus of its enterprise. The teacher became a co-developer, establishing greater reciprocity between teacher and students. Other students not in the course came in to help with art work. Many of the students continued on their own after the course to polish their work for use by the school in the spring. They also felt that their programs could be used by other schools, but their teacher and the counsellor felt that other schools would gain more by undertaking their own software development and so bringing the real student curriculum into the computer science classroom. In this example, students contributed to an enterprise of benefit to the entire school, an enterprise designed to minimize disastrous physical and emotional consequences of sexual activity.

*Example 4. A Case For Case-Study*

The senior computer studies course in Ontario (Ontario Ministry of Education, 1987) p-.-ovides a framework for student-directed, collaborative project work. Consider for example the first project done by a class under the guidance of their teacher before launching on projects of their own chosing. The school is host to an invitational track meet, an event that places considerable demands on record keepers. Developing a computer-based system and making it work well was therefore an interesting and realistic challenge for a class.

The course was an opportunity for growth not only in the students. The teacher, originally very skeptical about the course when it was introduced, and wanting a course that was a hard-core programming course, completely changed his view as he began to teach it. Clearly he had to deal with many teaching problems. He had to find effective and fair ways of involving students in distributing grades when working in teams. He had to find ways of encouraging the female members of the class to continue. Most important, he had to develop in his students the discipline they would need to carry out their own projects.

At the end of the course, students talked of their commitment and of the stark contrast to most of their other work in high school. One student who had matriculated but chose to take additional courses to broaden his education before attending university completely changed his attitude towards his work. Students who normally would not be concerned about missing classes would phone the school to say they would be coming even if they were only a few minutes late. The students valued highly having a say in the direction of the course and in doing work that was of direct benefit to others.

For the teacher, each time the course was offered, it had to be re-designed around suitable project opportunities and the interests of the students. The course was an important vehicle of professional development; it was a vehicle for developing a growth-oriented curriculum. The teacher began to adapt what he learned in the case study course to other lower level courses.

*Example 5. Home-grown Curriculum:*
*So Chickens Come From Eggs!*

Seeing fuzzy yellow chicks break through inside a styrofoam incubator in the living room of a small farmhouse surprised an apartment-dwelling teenager. That surprise surprised even more the student's science teacher, who had brought her class to the farm home where she, her brother, and husband are developing a small organic farm. They are juggling many variables, wanting to develop a market in which they sell organically grown herbs, vegetables, meat, milk, and eggs to local restaurants and individuals or food cooperatives. They also want to make their work a community learning experience through links with the local school board and faculty of education. Their work favors conservation through the technology of sustainable agriculture, a reciprocity with the earth. But that conservation extends to the community as marketplace, thus reducing costs of transportation of produce, and as school, thus ensuring that the benefits acruing to them — the satisfaction of a wholesome relationship with the environment and community — are shared with the community.

Environmental science courses will be offered in the summer and fall, courses in which computers will be used to organize and analyse data, to obtain reference information, and eventually for simulation and dynamic modelling. Of greater significance than the use of computer technology in these courses is the focus on holistic agricultural technology. Of greatest significance is the teacher's curriculum technology: she has adapted the course for students who have difficulty doing well in the regular classroom but who have practical interests and talents that will serve them well in an experiential education setting.

*Example 6. Phosphates In Our River:*
*A Local Contribution to a Global Problem*

In a small town on the St. Lawrence River, the system of sewage lagoons drains into a small river opening to the St. Lawrence. The local high school is dealing on several levels with recent concern about phosphate in the water and other environmental issues. First, the school has a history of environmental concern; students promoted recycling before the community officially established a "blue box" program for recycling paper, glass, and metal. Second, the school speaks to the community through a student-produced newspaper funded by local advertising and distributed free of charge to all school families. (The newspaper is produced by students taking a communications technology course.) A group of senior chemistry and biology students and their teachers have begun participation in the Global Lab Project (TERC, 1990), an international project in which scientists, teachers, and students collaborate on research related to ecology and the environment. These students and their teachers work in collaboration with university scientists, graduate students, and government agencies. For example, the students are taking samples for the provincial Ministry of the Environment. They are also involved in the local politics of the problem, and through the political astuteness of their teacher, are learning how to channel their concerns productively. Furthermore, students in technological studies and in computer science are providing support through organization of equipment, technical help with telecommunications, and publication.

Through the energy and enthusiasm of the biology teacher, the entire school is benefiting from resources acquired initially to support participation in the Global Lab Project. These resources include teleconferencing, spectrophotometry, weather monitoring, and most recently, downloading of satellite data. Furthermore, work at the school caught the attention of the federal Minister of the Environment who asked for information that she might use as an example in the House of Commons. This example is important because it shows how individual initiative can be linked to networks of similar initiatives so that local, activity can be of global benefit.

## RESTORING RECIPROCITY THROUGH WEBBING

Both of the last two projects mentioned are steps around rigid hierarchies — excellent for efficiently attaining predetermined goals—and towards building up flexible, heterarchical structures needed to cope with ever-changing circumstances, needed to minimize disaster. In both cases, use has been made of computer networking for communication among those most directly involved and to find out about the work of organizations dedicated to the same philosophy. The networks used are those of a Canadian non-profit computer conferencing service, Web (see reference list), connected to an international network of similar services (the Association for Progressive Communications) linking hundreds of activist, service, research, and educational groups. (Help on Web can be obtained by sending a message to "spider"!) How appropriate that the organization should chose as its name the remarkable structure built by spiders for survival. Buffeted by winds, rain, and passing animals, spiders continue to build and rebuild the webs they need until they die, adapting flexibly to each exigency.

Emerging democracies are showing great interest in international collaboration among scientists, educators, and students on addressing environmental and social problems. Communications networks form a promising, though still crude, medium for making local action globally usefu1. Scientists who participate in such collaboration are making major shifts in their careers as they begin to see how their specialized expertise can be of direct social and political significance.

## INFORMATION TECHNOLOGY, DEMOCRACY, AND EDUCATION

Journalist Patrick Watson in collaboration with scholar Benjamin Barber undertook a five-year quest to tell the story of democracy dramatically in a television series. At the end of the accompanying book (Watson & Barber, 1988), the authors raise basic questions on the direction of democracy, the last of which is whether technology is "freedom's hero or Dr. Frankenstein's monster".

> Technology promises to expand infinitely our capacity to control our environment, and to make and remake the human mind; it can do it in the name of human liberation, or on behalf of coercion and repression... The new technologies free us from the yoke of manual labour by centralizing power and expediting its efficient use, but they do this in ways that destroy the spatial and temporal walls that once created privacy, a sphere of rights, and room to breathe, (p. 267)

The same new information technology that serves institutional control can also strengthen individual voices, voices crying to protect human dignity and the environment. Watson and Barber give dramatic examples of individual enterprise in developing communication networks to generate coherent, effective voices of concerned citizens. In Colorado Springs, "electronic cowboy" David Hughes summons his "Electronic Legions" to debate public issues and influence legislators. Housewives in Zushi, Japan, link into a global communications network to summon the support of ecologists and environmentalists in staving off American incursions into the primeval Ikego rain forest. Technology education for democracy prepares voices in the classroom to build webs of communication that increase citizen participation.

Democracy, with all its inherent weaknesses — the unfairness of all voting schemes, the conflict of the rights of one individual with those of another, tension between individual rights and the common good, problems in accommodating cultural and religious diversity, and the awkwardness of supporting a pluralistic society through majority rule — is the system with which many countries govern themselves. However, the essence of democracy is not a political system of government but a shared disposition and set of values including: an interest in nationhood, law and order, civil rights, cultural diversity and richness, social justice, separation of church and state, and support for ideological pluralism. Its strength depends on an appropriate balance of representation — in which responsibility for legislation and action is transferred temporarily to trusted representatives, e. g. through election and through paying taxes — and participation — in which individuals and groups take upon themselves particular issues or causes. The more students assume genuine responsibility for participation by employing powerful new tools for shaping their school curriculum the more they will see democracy as requiring and benefitting from participation.

The teachers whose work is described in this paper understand the concerns that Franklin (1990) raised and have adopted a growth model for their work in which "context is what matters most." (p. 15). They care about justice, reciprocity, indivisible benefits, people, minimizing disaster, conservation, and reversibility; their cares are expressed in their actions. In basing curriculum on student themes, in supporting learning through social interaction, in crossing traditional discipline boundaries, and in collaborating with students on projects and case-studies, teachers help their students understand critically and constructively how technology, broadly defined as systematic practice, shapes the environment in which they live.

Franklin has raised our concern for justice, a justice coupled not with the power of mass control over megaprojects, but with the power of individuals coping with local exigencies, exigencies of the creative urge, of human relations, of human sexuality, of school life, and of providing safe water and healthy food. It is fitting then to end with a word on power from C. B. MacPherson (1965), after whose CBC Ideas lectures Franklin patterned her own:

> The societies which can best meet the demand of their own people for equal human rights, equal freedom for their members to realize their essential humanity, will be the ones that will survive... In the world from now on, power and influence will depend on moral advantage, (p. 66)
>
> The way to national power will be the recognition and promotion of equal human rights. And the pursuit of these ends will bring an enlargement of individual power as well, not the powers of individuals over others at the expense of others, but their powers to realize and enjoy their fullest human capacities, (p. 67)

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**IVLA** International Visual Literacy Association

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# The Use of Schema Theory in the Design and Development of an Interactive Videodisc Module: A Medical Example

Richard Hamilton
David Taylor

**Abstract:** Cognitive psychology represents a useful perspective for the designers and developers of interactive instruction. This theoretical stance not only forces us to investigate and evaluate the learners' knowledge state as they enter and undertake instruction, but it also offers specific and practical suggestions for the design and presentation of that instruction.

This article consists of two parts: First, the importance of particular characteristics of learning and the structure of knowledge (schemata) will be discussed from both a psychological and instructional perspective. Second, the instructional implications of expectations, interactivity and schemata will be illustrated in the design and development of a Level III Interactive videodisc module that teaches a highly-developed medical skill — the nursing response to a cancer patient with symptoms of infection. Specifically, the usefulness of the notion that knowledge is modular, thematic, and contextual is illustrated through a discussion of the videodisc segment which deals with a prototype case study of nursing practice.

**Resume:** La psychologie cognitive represente une perspective utile pour les concepteurs et les developeurs d'enseignement interactif. Cette theorie nous oblige non seulement a etudier et a evaluer le niveau de connalssance de I'etudiant au moment d'aborder un programme de formation, mais elle nous offre aussi des suggestions specifiques et pratiques en ce qui a trait a la conception et a la presentation de cet outil de formation.

Get article comprend deux parties: dans la premiere partie, nous verrons rimportance de certaines caracteristiques de I'apprentissage et de la structure de la connaissance (schemas) dans une perspective psychologique et didactique. Dans la deuxleme partie, nous mettrons en lumiere les implications didactiques des attentes, de I'interactivite et des schemas dans la conception et le developpement d'un module interactif Niveau III sur videodisque. Ils'agIt d'un module d'enseignement de techniques medicales hautement perfectionnees dont le theme est le comportement du personnel soignant devanf le patient cancereux qui montre des symptomes d'infection. Pour faire comprendre rimportance de savoir que la connaissance est modulaire, thematique et contextuelle, nous discuterons plus precisement de certains passages du videodisque exposant un cas type de traitement infirmier.

Rapid advances in medicine have forced health educators to identify ways of quickly translating new knowledge into practice. There is not only a need to train novice health professionals in the latest methods but to retrain expert health professionals to change existing techniques (cf, Benner, 1987; Curtis, 1988; Wolf, 1986). Current instructional design models utilize cognitive learning theories as the primary framework from which to derive instructional design and development principles and techniques (cf., Merrill, Li & Jones, 1990; Tennyson, 1990;

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Tennyson & Rasch, 1988). The newer models emphasize creating learning environments primarily concerned with aiding learners' in the acquisition, modification and employment of knowledge, and they contrast strongly with the traditional behavioral approaches to instructional design and development that have, until recently, dominated the field (O'Day, Kulhavy, Anderson & Malczynski, 1971). A basic premise is that changes in a learner's knowledge are a function of the interactions between the existing thought processes and knowledge, the organization and content of the materials to-be-learned, and methods employed to induce learning. The instructional designer must not only know what the learner brings to the instructional situation but must also consider the situations in which the knowledge to-be-learned will be retrieved and employed.

A cognitive approach to designing instruction that uses schema theory is described in this article. The importance of particular characteristics of schemata will be discussed from both a psychological and instructional perspective in order to represent use of medical knowledge. A self-instructional Level III interactive videodisc module that teaches a highly-developed medical skill is used to illustrate an instructional application of schema theory. Although the application is within a *medical context,* the principles are useful in other domains.

## SCHEMA THEORY

A major concern of cognitive psychology within the last 20 years has been how the nature and structure of knowledge influences its acquisition and use. A framework for representing knowledge which has been useful for summarizing research related to these issues is schema theory. Norman (1988) defines a schema as "a knowledge structure that contains general rules and information necessary for *interpreting situations andguiding behaviors"* (p. 86). In health care training, these two performance abilities would seem to be the primary knowledge domains that we want to impart through instruction. For example, the nurse follows a generalized "assessment schema" in order to interpret a situation when first seeing a patient — taking temperature, performing the physical examination, reviewing the history, and gathering other data, all of which culminates in a diagnosis. During this process, the appropriate schema that is specific for a condition (e.g., an infection) is activated. Once the diagnosis has been made, other schema are used to guide the care, treatment and follow-up phases of the process.

A fundamental assumption within schema theory is that learning is an *active, generative* process (Brewer & Nakamura, 1984; Thorndyke, 1984). Learning requires the *encoding* of new information by actively relating it to prior knowledge and experience. The generation of new connections between new and old should help learners successfully *retrieve* this knowledge in appropriate future situations. The possession of appropriate schemata have been helpful for both the active preservation of incoming information as well as for the active integration of new information with old knowledge (Bransford & Johnson, 1972;

Brewer & Treyens, 1981; Chi, Feltovich & Glaser, 1981; Dooling & Lachman, 1971; Dooling & Mullet, 1973; Stein, 1978; Thorndyke, 1977; Thorndyke & Hayes-Roth, 1979). Activation of appropriate schemata have been found to be helpful as guides for searching for schema-related information and knowledge and eventual retrieval of this information (Anderson & Pichert, 1978; Anderson, Reynolds, Schallert & Goetz, 1977; Bower, Black & Turner, 1979; Kintsch & Green, 1978; Pichert & Anderson, 1977).

According to schema theory, *learning is also purposive (anticipatory).* In addition to guiding retrieval of relevant information, a newly activated schema will elicit expectations and a certain amount of pre-determined behavior. Schemata for responding to very familiar situations are sometimes called scripts (e.g., going to a restaurant) (Abelson, 1981; Kuzma, 1989) that presumably allows us to perform certain tasks automatically and even concentrate on other tasks at the same time. Unfortunately, this same process is responsible for our tendency to commit errors.

Learning, as used here, broadly refers to the gathering of data within certain familiar and well-established patterns, as well as the assimilation of new and unfamiliar information (such as how one would learn in school or in an apprenticeship situation). Rumulhart and Norman (1981) assert that schema theory implies three different types of learning, based upon the extent of modification of prior knowledge. Accretion is the most common type, in which new information is simply interpreted and assimilated in terms of pre-existing schemata. Tuning implies modification of an existing schema, while restructuring is the most extensive, possibly requiring the creating of new schema. For example, major errors could occur if a nurse were to gather data from a patient simply by activating a pre-existing schema (accretion), when in fact that schema actually required major revision (by tuning or restructuring). The point is that a schema, once activated, will heavily influence the data to which a person will attend.

Three other characteristics of schemata also have important implications for the design and development of instructional materials. The modularity of schematic knowledge, the prototypicality of concepts subsumed within schemata, and the contextual nature of schematic knowledge.

*Modularity of Schemata*

Schemata consist of: 1) an organized set of prototypical concepts which describe knowledge related to a theme (i.e., declarative knowledge); 2) the procedures for adding to and using this knowledge (i.e., procedural knowledge); and 3) the conditions under which it is most appropriate to use this knowledge (i.e., contextual knowledge) (Rumelhart, 1980; Tennyson & Rasch, 1988). Declarative knowledge is developed through the storage and integration of critical defining dimensions of concepts and typical examples of these concepts; procedural knowledge is developed through retrieval of declarative knowledge and application of this knowledge to novel situations; and contextual knowledge is developed through the application of declarative and procedural knowledge to situations which reflect the contexts within which this knowledge will be applied (cf., Bransford, Vye, Adams & Perfetto, 1989; Deny, 1990; Nitsch, 1977; Tennyson & Cocchiarella, 1986; Tennyson & Rasch, 1988).

A nurse's schemata of a particular medical condition or illness will involve knowledge of typical symptoms related to the condition, procedures for integrating relevant information related to the illness as well as for the use of their knowledge during medical interventions and the situations or contexts in which using this knowledge is most appropriate. For example, in a schema for infection, the nurse would have declarative knowledge related to recognizing, assessing and diagnosing symptoms of infection, procedural knowledge related to the formulation of a plan of care for that patient, as well as contextual knowledge which would indicate when and why to use specific approaches to care. Schemata can have very specific themes or more general ones and those that are more specific are often imbedded in the more general. Thus, large, global schemas are thought to contain subschemas for simpler types of knowledge, with the schemata for different domains having very different structures (Brewer & Nakamura, 1984).

*Prototypical Nature of Schemata*

Schemata describe the thematic characteristics that will tend to be true of most instances to which the schema can be applied. Consequently, they are 'prototypical.' Much of our knowledge can be described in terms of prototypes or "best examples" (Anderson, 1990; McCloskey & Glucksberg, 1979; Rosch, 1978; Walker, 1975) and presenting prototypes can enhance learning. For example, research on concept learning has found that presenting prototypes of to-be-learned concepts produces higher levels of concept acquisition than presenting students with definitions and descriptions of critical attributes (Dunn, 1983; Jonassen, 1988a; Park, 1984; Tennyson & Cocchiarella, 1986; Tennyson, Youngers & Suebsonthi, 1983; Yoho, 1986). The value of schemata lie in their ability to recreate a useful thematic context for the acquisition and retrieval of appropriate knowledge. The degree to which schemata can supply appropriate contextual information will significantly influence a learner's ability to acquire and eventually use knowledge.

*Contextual Nature of Schemata*

In addition to the thematic context, knowledge related to the context of instruction and the context of use of the learned information will tend to be more fully integrated within schemata. Any attempt to induce learners to acquire new knowledge or modify old knowledge will need to focus on inducing the encoding of this knowledge in a context similar to those where it is expected to be retrieved. The thematic quality of schemata information provides some contextual information, but information about when knowledge should be used should be presented when it is acquired.

Of particular interest is the application of knowledge to novel problem solving situations. Research has found that learners often do not access available and appropriate knowledge when faced with novel problem-solving tasks (Bransford, Franks, Vye & Sherwood, 1986; Bransford, Sherwood, Vye & Reiser, 1986;

McNamara, Miller & Bransford, in press; Sherwood, Kinzer, Bransford & Franks, 1987) . Even though the learners have previously demonstrated that they possess appropriate knowledge to solve the novel problems, when faced with these novel problems, they often do not access this knowledge (see also Adams, Kasserman, Yearwood, Perfetto, Bransford & Franks, 1986; Gick & Holyoak, 1983). These results are consistent with other research which found that relevant declarative knowledge (e.g., lists of words) and procedural knowledge (e.g., study strategies, problem solving strategies) are often not spontaneously accessed when appropriate (Brown et al., 1983; Simon & Hayes, 1977). If the learner is expected to apply the target knowledge in novel problem situations and not previously presented ones, then the teaching activities and materials must induce processing appropriate to developing novel problem solving ability. For example, if the future task of the learner is to perform diagnostic evaluation through interacting with a patient, then the diagnostic skills and related information should be taught within this context. Tasks which closely approximate the context (both environment and processing context) within which the newly learned skills will be applied are identified as "authentic tasks" (Bransford, Sherwood, Hasselbring, Kinzer & Williams, in press; Cognition and Technology Group at Vanderbilt, 1992). The use of authentic tasks during instruction should improve the quality and transfer of learning. Interactive videodisc presentations are ideally suited to involve learners in "authentic" tasks (McNamara, Miller & Bransford, in press.)

In summary, the application of schema theory to the design of instruction would require the development of activity-oriented instruction which focuses on the characteristics of existing learner knowledge, the to-be-acquired knowledge, and the future context within which this knowledge will be employed. In the next section, guidelines for the application of schema theory to instructional design and a description of a specific application will be discussed.

## AN INTERACTIVE VIDEODISC EXAMPLE

Aspects of schema theory were applied in the design of an interactive videodisc (IVD) teaching nurses about infection in cancer patients. The IVD program in this example was developed as an outgrowth of the educational needs of a comprehensive cancer center, whose activities cover clinical and basic research, patient care, cancer prevention and education. Professional education is an active area, and instruction is offered to medical students as well as practicing physicians, nurses, and allied health professionals on an array of subjects covering the field of clinical oncology.

The department of nursing in the cancer center is especially active in professional education, and some members of the staff teach a number of courses in addition to their patient care and other responsibilities. The specialized nature of the subject matter presents a special challenge. Instruction cannot be offered in standard college-style fixed-length courses, because instructional units may require from a few hours to several months to complete. There are also issues of convenience and cost-effectiveness for both the instructors and the students, who are often working nurses, graduate students or higher level undergraduates who rotate through the center from other nursing schools. Scheduling convenient times for these courses can present some difficulties. For some parts of the curriculum, therefore, independently operated self-instructional media, such as interactive video, seem to offer a practical solution.

The disc's design involved using different strategies and approaches within the same module to address different instructional needs. The design called for five major program segments: a) a pre-test to diagnose the nature of the learner's knowledge; b) a tutorial segment to initially remediate those learners who begin the program with knowledge deficiencies and to which students could be referred for additional knowledge during the more active or problem-oriented segments of the program; c) a prototype case study segment which involves nurse experts modeling a prototypical approach to a 'generalized' or typical case study; d) practice case studies presented within the context of the clinical nursing situation in which these skills and knowledge must be recalled and applied, and e) a post-test designed to prepare students for oncology certification.

The focus on the learner's prior knowledge, the nature of to-be-learned knowledge, the need for active-oriented methods and the importance of the context of future use of to-be-learned knowledge are exemplified in these segments. For example, the pre-test segments assesses learner prior knowledge, while the tutorial segment provides remediation for gaps in learner prior knowledge. Also, both the prototype case study and practice case study segment involve the learner in active processing of target knowledge and "authentic' activities which mirror the real-life contexts within which this knowledge will be applied.

One could argue that a traditional instructional design framework (cf., Dick & Carey, 1990) would approach the current situation in a similar way and that the instructional product would parallel the segments described above. For example, a traditional approach would attempt to identify important learner knowledge and skills within the task analysis phase and create instruction and remediation to deal with learner needs and deficiencies. However, the application of schema theory to the instructional design process requires more than a cataloguing of learner skills and knowledge. That is, there is a need to carefully identify how the to-be-learned knowledge, the contexts of its future use and learner prior knowledge should be integrated within the instructional and evaluation methods employed during instruction. TVD technology is ideally suited to easily accommodate the integration of these aspects within instructional methods.

The application of schema theory to the instructional design and development process can best be demonstrated within segments which depend primarily on rVD as the method of instruction, i.e., prototype case study and practice case study segments. Within the following sections, guidelines for instructional design and development derived from schema theory will be illustrated within the context of the prototype case study segment.[1]

*Prototype Case Study*

This segment presented a dramatization of a cancer patient who comes to a community hospital complaining of feeling somewhat under the weather — "lousy." The patient's complaints are deceptively mild: a small (1-2 degrees) rise in temperature and a slight pain in the chest, symptoms which, in an otherwise healthy patient, would not seem to warrant concern. However, given the patient's history of cancer and a recent, strenuous chemotherapy regimen, the oncology nurse-expert recognizes the early signs of a developing infection (pneumonia). In conjunction with the physician's diagnosis, she responds appropriately with an aggressive attack on the symptoms. Discussion of other important features of the prototype case study will serve to illustrate the guidelines discussed in the following sections.

## *Guidelines for Instructional Design and Development*

From schema theory and research, the following instructional guidelines were used in the design of the prototype case study segments: 1) identify useful *facilitative and interfering learner knowledge* and design instruction to take into account potentially facilitating learner knowledge and interfering learner knowledge; 2) given *the prototypical nature of knowledge,* typical situations and content should be employed throughout instruction in order to facilitate the process of acquiring new knowledge; and 3) instructional methods and activities which include *the contextual cues available during the future use of target knowledge* should be developed in order to insure that learners can gain access to the target knowledge during future use; 4) *multiple types of activities* should be developed to help learners acquire the variety of knowledge which supports useful learning outcomes; and 5) since learning is an active generative process, *activity-oriented techniques and methods* should be developed for use during instruction.

*Identification of Facilitative and Interfering Learner Knowledge*

Schema theory tells us that learners — especially adult learners with considerable professional experience, as in our example — bring a great deal of information with them in the form of complex schemata (cf., Egan & Schwartz, 1979). These pre-existing schemata have a powerful influence on how we learn new information, and the instructional designer must be aware of these schemata and how they are likely to affect students' performance.

The intended audience consisted of practicing, experienced nurses seeking oncology certification or continuing education credit. They were expected to have well-developed, basic nursing skills, including an understanding of (a schema for) the nursing response to typical conditions, such as infection. Unfortunately, the response to infection in a normal patient and a cancer patient must differ markedly. Simply put, the immune system — the body's defense against invading microorganisms — is usually severely weakened (compromised) in a cancer patient, with the result that infection can cause severe illness and even death within a matter of hours after the appearance of symptoms. Therefore, the health care response should be much more rapid, aggressive, and specific than with a normal patient. In addition, the first symptoms of infection can be very subtle — as little as a one-degree change in temperature can signal a dangerous condition. It is not surprising, then, that a large part of the instructional process in this area consists of correcting misconceptions in nurses who are accustomed to caring for patients with intact immune systems.

Two aspects of the nurse's prior knowledge were identified as important to the acquisition of appropriate schema for dealing with infection in cancer patients. First, most nurses are trained to use a specific problem solving process for dealing with new patients which is refered to as "nursing process" (Henderson, 1982; Alfaro, 1986; Yura & Walsh, 1988). Students usually learn this approach through a mnemonic, *ADPIE,* which stands for Assessment of the condition, Diagnosis, Planning the health care approach, Implementation of the health care plan and Evaluation of the plan. Nursing students not only study case histories with this approach, but they are also taught to use it in their clinical practice. Expert nurses also follow this process, although they typically do not consciously work through each of its steps. The prototype case study used this process as an overall framework for familiarizing nurses with the procedures for dealing with infection in cancer patients. At the outset, the viewers are simply shown the patient's presenting complaint. After the presentation of the complaints, however, they are induced to join into the nursing process. For example, they are given a choice of the order in which to conduct the assessment procedures, but they must conduct all procedures (in the form of choosing appropriate procedures from a menu) before they move on to the next stage of the process. The integration of the new skill within the context of this familiar nursing process schema takes advantage of the facilitative effects of their existing schema-based knowledge.

Secondly, the student nurses already had a relevant schema for dealing with infections. However, the nursing instructors had determined that their students' schema required "tuning" in order to modify it to include the special case of cancer patients. Consequently, the instruction highlighted how infection in a cancer patient requires a different approach and focused on the development of a "retuned or restructured" schema for dealing with this condition. For example, the combination of presenting symptoms in a 'normal' patient would not be treated as aggressively as they would in a 'cancer' patient. Also, given the vulnerability of cancer patients to infection due to their compromised immune systems, the critical importance of procedures that are often taken for granted (e.g., patient hygiene) are highlighted. Hence, the potential interfering effects of this prior knowledge was identified, and the instruction was designed to deal with this potential effect.

*Prototypical Nature of Knowledge*

*As* described earlier, we often know the world through prototypes (Anderson, 1990), and svudents learn effectively when prototypes or "best examples" are presented for students to study or model (Tennyson & Cocchiarella, 1986). Within the present context, a critical part of the instructional design process was, then, to identify and create a prototype which captured the most important aspects of the target situation and application of this skill within this situation.

Two subject matter experts (oncology nursing instructors) in conjunction with the instructional designer (no medical knowledge) were responsible for creating the case study which would serve as the test example' or 'prototype' of a cancer patient with infection. They used the 'nursing process' as a guide to developing the case study. That is, they focused initially on aspects of assessment and diagnosis (symptoms, patient characteristics, etc.) and then identified the specific steps, implementation and evaluation of the treatment plan as it relates to this 'prototype' case study.

As indicated earlier, the 'prototype' consisted of a patient (male, over 60) who has a pneumonia infection, growing in the lungs, resulting from a compromised immune system, which occurred as a result of a strenuous chemotherapy regimen. Given this typical case as a framework, the SME's then worked backwards and identified the type of symptoms the patient typically would notice and complain of (i.e., slight fever, pain the chest that would not respond to Tylenol), what his lab test results would be, etc. They also included subtle but crucial symptoms that a non-oncology nurse might not notice or not take seriously (e.g., importance of a slight one degree increase in body temperature as an indication of an oncoming infection). Also, they identified how the planning, implementation and evaluation would differ in this situation in comparison to dealing with a non-cancer patient with infection, For example, because the patient is more vulnerable to infection, certain procedures are critical to follow and include during treatment (e.g., frequent handwashing and other precautions for the patient's hygiene). Given the nature of the existing schema (i.e., thematic), focusing on 'typical' characteristics and events within this setting should facilitate the modification of the existing schema and the creation of a new schema related to infection in cancer patients.

*Importance of Contextual Cues*

The more closely a learning situation matches the situation in which it will be used, the more likely the information will be used appropriately and correctly (Cognition and Technology Group at Vanderbilt, 1990). Schemata not only contain content knowledge, but they also contain contextual cues that tell us when and where it is appropriate to use that information (Tennyson & Rasch, 1988). These contextual cues consist primarily of situational and processing cues. Situational cues consists of the characteristics of the situations in which target skills and knowledge will be employed (e.g., specific hospital settings such as the patient's room during the work-up exam, in conference with the attending physician, etc.) and processing cues, which consist of the nature of tasks in which the target skills and knowledge will be employed (e.g., problem-solving, diagnosis). Instruction presented via interactive video can automatically provide the appropriate context for the cues that delimit the type of environments, problems and tasks within which the knowledge is appropriate.

The analogy of this program segment to an apprentice-master relationship is intentional. This section is conducted very much like a student nurse following a master nurse though a complete case; just as in a real clinical situation (during rounds, for example), the master nurse pauses to ask questions: do you understand this? what does this mean? what would you do at this point? For example, when the lab results come back, the program pauses and asks, which of these tests are most indicative of infection? Also, during the plan implementation section, the student is not asked what to do, but instead, why are the existing procedures important? The student is not only presented with important knowledge and skills within important contexts but is also asked to reflect on when to apply appropriate skills and why their application is important.

*Multiple Types of Activities*

Schemata consist of declarative, procedural and contextual information related to people, events and objects (Shiffrin & Dumais, 1981). Although other forms of instructional delivery (i.e, lecture, computer-aided instruction) can adequately induce learners to acquire appropriate declarative and procedural knowledge, IVD is ideally suited to induce learners to acquire declarative, procedural and contextual knowledge. More importantly, relevant contextual knowledge can serve as the framework within which target declarative and procedural knowledge can be presented. Hence, the instruction is organized around important contextual information. That is, target concepts, skills, behaviors, facts, etc., are grouped together according to how they will be employed, rather than in some hierarchical or "logical" order (see Tennyson, 1990). The prototype case study was organized around a specific hospital setting using the 'nursing process' as a framework for interacting with the patient. The important diagnosis, assessment and planning skills and concepts were integrated within this contextual base. For example, during the initial skin assessment, the nurse discovers petecchiae (hemorrhagic spots caused by weakened capillaries); the program pauses and points out the spots, identifies them, and then offers a textual definition of petecchiae for the learner to review (focus on declarative knowledge). A standard CAI program might have isolated the definition of petecchiae within a tutorial or glossary, far removed from where the information is needed or applied. Also, the master nurse asks the viewer questions concerning their understanding of case information, the appropriateness and meaning of test results, the most appropriate next step in dealing with the patient, etc. These questions are aimed at the development of appropriate procedural knowledge. Most importantly, they develop this knowledge within the context of its future use.

*Active-Oriented Instructional Methods*

As described earlier, schema theory characterizes learning as an active, generative process; it has been widely noted that one of the strengths of interactive, ccinputer-based learning programs is their capability to provide that very type of active learning situation (Jonassen, 1988b). In its simplest form, the computer program can be programmed to wait until the learner responds to a question, as in drill-and-practice or simple tutorial programs. In more sophisticated applications, programs can closely simulate the same type of activity required in the performance of clinical duties. For example, interactive video can simulate realism to the extent that learners perform patient interviews and interact with patients in an emotionally involving way (Harless, 1986), and indeed, the addition of video to a more conventional CAI program has been shown to improve students' performance in and attitudes toward instruction (Dalton, 1986).

Many examples of the use of active processing techniques within the prototype case study segment have been described previously. For example, viewers were asked to answer questions relating the nature of techniques employed during assessment and treatment of the prototype patient. Also, they were asked to reflect on the veracity of their knowledge of important concepts and given the opportunity to refresh their knowledge of these concepts. Finally, viewers were asked why certain medical techniques and procedures should be employed. All these methods induce the viewer to actively process and manipulate target knowledge.

## CONCLUSIONS

This paper has presented guidelines based on schema theory for the design of instructional material. From schema theory and research, the following guidelines were derived: 1) identify useful facilitative and interfering learner knowledge prior to beginning the design process, and design instruction to take advantage of facilitating learner knowledge and to overcome potentially interfering learner knowledge; 2) given the prototypical nature of knowledge, typical situations and content should be employed throughout instruction in order to facilitate the process of acquiring new knowledge; 3) instructional methods and activities which include the contextual cues available during the future use of target knowledge should be developed in order to insure that learners can gain access to the target knowledge during future use; 4) multiple types of activities should be developed to help learners acquire the variety of knowledge which supports complex learningoutcomes; and 5) since learning is an active generative process, activity-oriented techniques and methods should be developed for use during instruction. Employing these guidelines within the instructional design and development process will produce instructional materials that are consistent with current theory and research on learning, the nature of knowledge and knowledge change. This should result in effective instructional materials.[2] Finally, as illustrated in this paper, these guidelines can be more easily integrated into the instructional design process within the context of IVD technology due to the interactive, contextual and authentic nature of this technology.

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## NOTES

[1]Since the practice case study segment builds on the initial prototype case study segment, the latter was chosen to showcase the value of schema theory for the design of P\D-based instruction.

[2]The prototype case study module has been adopted and integrated into nursing curricula across the United States and has won two national awards for superior interactive media product. Although there is clearly a need to formally evaluate the instructional and cost effectiveness of the described module, at this point, the willingness of many nursing schools to integrate the module into their curricula can be used as an indirect measure of its instructional and cost effectiveness and the value of the development process.

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# An Investigation of Learner Characteristics and Instructional Control on Grade Five Students

Penelope Anne Nicholson

**Abstract:** Eighty-five grade 5 subjects were randomly assigned to one of three treatment groups (learner-controlled, yoked-controlled, or program-controlled) In order to investigate if the type of control affects achievement when using computer-assisted instruction. The study used one independent measure, four covqriates, and three dependent measures. The independent variable was type of control which was the student's free choice (learner-controlled), or forced viewing of some (yoked-controlled), or all (program-controlled) of the five assistance options designed to enhance comprehension, The assistance options were aimed at improving the students' ability to answer multiple choice questions regarding four 150-300 word passages on software called "The Comprehension Connection." The first and second covarlate were ability as determined by the Verbal and Nonverbal Subtests of the Cognitive Skills Subtest of the Educational Development Series battery of tests. The third covariate was Age of the subjects at the time of the treatment, and the fourth covariate was the personality characteristic of Locus of Causality as measured on the Intellectual Achievement Responsibility Questionnaire. The dependent variables were achievement as measured on a post test, the results of an attribution test which determined thesubjects' causal belief about the computer situation, and the time required to complete all the passages in order to determine the efficiency of the three treatments. An analysis of covariance revealed a main effect for control, and the results indicated that program control produced higher achievement on the post test than for the learner controlled group. No other significant differences were found.

**Resume:** On a affecte au hasard 85 eleves de cinquieme annee a trois groupes de traitements differents. Un groupe, maitre de son propre apprentissage (learner-controlled), un autre dependant du premier c'est-d-dire des options appariees (yoked-controlled) et un troisieme dependant du programme lui-meme (program-controlled). Cette etude avait pour but de determiner si le type de controle affectait la performance dans I'apprentissage assists par ordinateur. Unemesure independante, quatre mesures preliminaires et trois mesures dependantes ont ete utilisees. La variable independante etait le type de controle libre-choix de I'eleve (learner-controlled), ou I'obligation de choisir certaines options appariees (yoked-controlled), ou, I'obligation d'utiliser chacune des cinq options offertes par le programme (program-controlled). Les options d'assistance visaient 6 ameliorer I'habilete de I'eleve a repondre aux questions a choix multiple sur quatre passages de 150 a 300 mots dans le logiciel Intitule "The Comprehension Connection." La premiere et la deuxieme mesures preliminaires etaient I'aptitude telle qu'elle avait ete determinee par les Sous-tests verbal et non verbal (Verbal and Nonverbal Subtests) du Sous-test des aptitudes cognitives (CognitiveSkills Subtest) de la serie de tests de developpement pedagogique (Educational Development Series). La troisieme mesure preliminaire etait I'age des sujets et la quatrieme, la caracteristique de la personnalite du Locus de causalite telle qu'elle a ete determines par le questionnaire Responsabilite de la Reussite Intellectuelle (Intellectual Achievement Responsibility Questionnaire). Les variables dependantes etaient la reussite telle qu'elle a ete mesuree par un post-test, les resultats d'un test d'attribution qui determine!) les convictions causatives dessujets en situation devant l'ordlnateur, et le tem ps requis pour com pleter tous les passages afin de determiner le rendement de chacun des trois traitements. Une analyse des mesures preliminaires a revele que le controle affecte la performance, et les resultats ont montre que legroupesoumis au controle program me a obtenu de meilleurs resultats lors du post-test que le groupe affecte au traitement libre choix. Aucune autre difference marquante n'a ete relevee.

With educational funding decreasing and class size increasing, it becomes essential to help overburdened teachers produce and select learning systems that will meet the needs and individual differences of various learner types. Learner-controlled instruction is an instructional strategy wh ich attempts to optimize the learning situation by allowing the learner to make one or more of the key instructional decisions or selections. The learner can select options such as the pacing, sequencing, content, timing, amount of practice, and/or the difficulty level. With this design the learner controls the instruction, while the instructor or programmer controls the environment, the set of conditions which will produce predictable learning results even though the learner makes one, some, or many of the learning decisions (Wydra, 1980).

*Research on Learner-Control*

Mager (1963) conducted early work in the area of learner control, and emphasized that learners come to a teaching situation with varying amounts of relevant knowledge regarding a lesson, and therefore shou Id be given control over the sequence, pace, length, and/or content of the curriculum in order to achieve specified objectives. Mager (1963) concluded that providing the learner with control increased learning effectiveness by reducing the length of formal training, while at the same time improving the competence and confidence of the learner.

Placing the control in the learners hands may appear to solve the problem of how to individualize instruction, but though some groups have been seen to strongly benefit from it in terms of performance (Mager, 1963; Campanizzi 1978; Kinzie et al. 1987) , the research has shown that other groups do not react favorably towards this control as learners were seen to be ineffective in managing their own instruction (Olivier, 1971; Judd, 1972; Fisher, Blackwell, Garcia, & Greene 1975; Lahey, 1978; Lahey et al., 1978; Reinking & Schreiner, 1985). Still other experiments found that providing learners with control had no effect on performance (Alpert & Bitzer, 1959; Judd, 1972; Merrill et al., 1980; Goetzfried & Hannafin, 1985; Holmes et al., 1985; Reinking, 1988).

It is clear from this research that the findings have yielded mixed results and generalizations are not yet possible, however to clarify this issue, it may be necessary to investigate not only the effectiveness of control, but also its efficiency. Results of studies that investigated the efficiency of learners on computer-assisted tasks which provided instructional control, however, have also been mixed. Research has found that providing learner's control of instruction was a more efficient strategy (Alpert & Bitzer, 1970; Fredericks, 1976), more time consuming (Goetzfried & Hannafin, 1985), or was seen to make no difference (Lahey, 1978; Lahey et al., 1978).

The researchers who found that providing the learner control of instruction was more efficient than conventional program-controlled instruction, or that providing control made no difference in terms of time, carried out their research on the TICCIT and PLATO mainframe systems. These large computer systems allowed the learner to exercise choice over numerous facets of instruction such as choice of next content and display type, rule frames, examples, practice problems, and test items (Merrill, Schneider & Fletcher, 1980). It is difficult to determine which features of control were, or were not, efficient, and whether these findings can be generalized to microcomputer instruction. The researchers who found learner control more time consuming than program-controlled instruction (Goetzfried & Hannafin, 1985) conducted their study under more strict experimental CAI conditions, and investigated the use of control by providing learners control of review and selection of examples. Results of this study indicated that the linear control group, which was not provided with control, had comparable learning in less instructional time than learners provided with computer-controlled branching (adaptive control), or learner control with advisement. This study's results are interesting and merit further investigation, because if school children cannot efficiently utilize the control provided in microcomputer software they are likely not mastering the material, which could be magnified by the often restrictive lab or classroom time available for the student on the computer.

Another area of interest besides the effectiveness and efficiency of instructional control in CAI, is its effect on the attitude of the learner. If providing the learner with control of some aspect of instruction can foster positive feelings toward the learning experience, then it may serve as a motivational tool that may help to optimize the learning situation. Past research, however, provides conflicting guidance as some researchers have found that subjects developed a more positive attitude when provided with learner controlled instruction (Merrill et al, 1980; Kinzie et al, 1987), while others found this control had no effect on student's attitudes (Lahey, 1978; Lahey et al., 1978; Reinking, 1988).

It is clear from the review of the research that it is not yet possible to clearly determine how providing learners with instructional control affects performance, instructional time, and attitudes. Questions arise as to whether instructional control should be provided, and if it should be provided to all learners. It is well known that learners possess different characteristics, but it is unknown how students' attributes interact with different levels of instructional control. Student's attribution of the learning situation (their perceived causal relationship between their actions and the consequences that follow) as well as their ability will be the learner characteristics investigated in this study.

*The Interaction of Student Characteristics and Learner Control*

Attribution theorists propose that there are three major dimensions of causality — locus, stability and controllability- and that one's perception of these dimensions affect one's emotional experiences (Weiner & Kakla, 1970; McMahan, 1973; Weiner, 1985). Locus of Causality is of particular importance to the educator because of its perceived relationship to an individual's self-worth and self-esteem. Attribution theorists claim that success attributed to internal causes, such as ability or effort, generates feelings of pride and positive self-esteem, while failure attributed to internal causes generates a negative self-image (Weiner & Kakla, 1970; McMahan, 1973; Weiner, 1985). These researchers also state that positive and negative outcomes attributed to external causes, such as luck or unfairness, do not affect self-esteem. It is especially important to investigate how children view their academic experience, as it is hypothesized that learners who attribute failure as being due to internal causes are less likely to consider adverse circumstances as surmountable, and will, perhaps, give up in the face of failure.

It is also important to investigate how instructional control and a learner's locus of causality *interact* in the learning environment. Holloway (1978) and Hannafin (1984) hypothesize that learners with internal attributions may achieve higher performance than those with external attributions, and that externals may perform better in situations where structure is provided for them, while internals may perform best when little structure is provided.

Research on the effect of locus of causality and learner control on performance, however, has yielded mixed results (Daniels & Stevens, 1976). Little research in this area, however, has investigated this issue in the context of computer-assisted instruction. One study of interest that did investigate this issue with CAI found that a learner's locus of causality did interact with the degree of instructional control provided to the learner (Carrier, Davidson, Higson, & Williams, 1984). Carrier et al. (1984) found that students high in externality performed better with fewer instructional elaborations in a computer-assisted task, while internals' performance was not affected by the extent of the instructional elaboration and performed best with a greater number of options. A later study by Lopez and Harper (1989), however, did not support these findings. Lopez and Harper found that internal locus of control subjects did not perform better than externals when provided with a high level of learner control in a CAI task. Other recent studies with CAI, found that while locus of causality significantly influenced performance, type of instructional control did not affect outcomes (Klein & Keller, 1990), and that high internals performed best whether instruction was in the control of the learner or largely under the program's control (Gray, 1989). Research on locus of causality as it affects performance, therefore, provides conflicting guidance. From the review of the attribution research, questions arise as to whether differences in performance would be evident in subjects with an internal or external locus of causality when provided with different levels of instructional control. Further research in this area is needed in order to gain information to help optimize the learning situation.

The second learner characteristic of interest in this study is the issue of ability and its relationship to instructional control. Researchers hypothesized that low achievers may not perform well when provided with instructional control. One study found that low achievers did not select options that provided more instruction as needed, but rather were forced into elaborate feedback loops after making a series of errors (Belland, Taylor, Canelos, Dwyer, & Baker, 1985). These researchers also hypothesized that moderate external pacing might improve performance and overall time efficiency for task completion. They concluded that students may not be the best judges as to how much, or what type, of instruction they need for effective learning to take place.

Another interesting study found that young low-ability students provided with learner control with advisement required more time to complete the tasks, with no associated gain in achievement, while a linear control group had comparable learning in less instructional time (Goetzfried & Hannafin, 1985). Thus, for low ability subjects the most efficient strategy was to receive a set sequence of instruction with no advisement, no control of review or selection of additional examples, and no externally imposed program decisions based on the accuracy of responses.

The reason for the poor performance of low-ability subjects when provided with learner control has not been fully investigated, but it may be attributed to the student's lack of ability to determine when remedial help was needed; a skill which Judd (1975) stated was a reason for learner control being superior over program control in average and above average adults. Tobias (1981) and Bovy (1981) predicted similar results and stated that it is logical to expect an inverse relationship between prior achievement and the amount of instructional support the learner needs.

Snow (1980a) also supports this observation that low-ability subjects perform poorly when they are provided with instructional control. Snow (1980b) stated that "directed-learning", or program control, may do for low ability students what they cannot do for themselves, but that this type of control may be dysfunctional for more able students who are capable of organizing their own learning. Program-controlled microcomputer instruction may be a superior method in teaching young and less able learners, but further research must be conducted in order to gain support for these hypotheses.

The problem addressed in this study was what type of control should be provided to learners with various abilities and characteristics in order to create an effective, efficient, and motivating instructional environment? The issues investigated in this study are interesting and important because the designer of technologically-based instruction, especially computer-based instruction, has the potential to provide as much, or as little control, as is required by the learner in order to optimize the learning environment (Hannafin, 1984). Teachers and designers must, therefore, be provided with information in order to determine how control in a computer situation should be granted, to whom, and under what conditions.

The purpose of this study was to gather practical information by investigating the reading comprehension of grade five students with a computer program, and to examine this issue from the perspective of learner versus program-controlled instruction, and whether the use of this control was affected by perceived control, the strategy used, or the learner's ability. It was hoped that this information would assist teachers and designers in clearly determining the reaction of different groups towards the types of control available in computer software.

*Research Questions and Hypotheses*

The questions this study attempted to answer were whether there was a difference in performance on a post test between groups provided with different types of instructional control, specifically learner-controlled, program-controlled, or yoked-controlled instruction. Each type of control is explained fully below. Another question dealt with the relationship between performance on the post test and the learner's characteristics: verbal ability, nonverbal ability, age and locus of causality.

The study also investigated whether there was a relationship between the time taken to complete the reading task, the type of instructional control, and a learner's ability and locus of causality. The last question investigated whether there was a difference in attitude between subjects in the learner-controlled, program-controlled, and yoked-controlled groups?

*Hypotheses*

It was hypothesized that:

- there would be an aptitude-treatment-interaction (ATT) between ability and program control.
- subjects with low ability would perform poorly in the learner-controlled treatment, and be out-performed by low ability subjects in the program-controlled treatment.
- subjects with high prior achievement would perform best in the learner-controlled treatment.
- subjects who took responsibility for their intellectual academic successes and failures (internals) would out perform those who failed to take responsibility (externals) on the post test.

## METHOD

*Subjects*

The subjects in this study were 85 upper-middle and middle class children of mixed ability, between theages of 10 and 12 with a mean age of lOyears 7 months. They were drawn from four grade five classrooms in a public school. The elementary section of this school has used microcomputers for several years so no novelty effect was expected when the computer treatments were introduced.

*Design*

The study used one independent variable, four covariates, and three dependent variables in order to investigate computer-assisted instructional-control.

The independent variable in the study was control, and the subjects were randomly assigned to one of three treatments, either program-controlled (n = 27), learner-controlled (n = 29), or yoked-controlled (n = 29). The three treatments are discussed below.

The subjects in *the program-controlled group* were required to use a program designed to enhance reading comprehension, read an on-line passage, and then view five assistance options in a preset order. The assistance options were meant to aid the subjects in comprehending four reading passages in order to answer five multiple choice questions per passage.

The subjects in the *learner-controlled group* were able to select assistance options, and were required to read an on-line passage, and then choose the number and order of the five available assistance options. The assistance options were meant to help the subjects in comprehending the four reading passages in order to answer five multiple choice questions per passage.

The subjects in *the yoked-controlled group* were required to read an on-line passage, and then view a limited number of assistance options in a preset order to aid in comprehending the four reading passages and answer five multiple choice questions per passage. Each yoked-controlled subject was matched with a subject from the learner-controlled group, and the options which were presented to the learners in the yoked-controlled group were based on the strategies used by their matched subjects from the learner-controlled group. In other words if a learner in the learner-controlled group chose to view only the 'Return to Passage' option, and 'Graphics' option for passage number one, then the matched yoked-controlled subject would be provided with only these options for the same passage. Likewise, if a learner-controlled subject decided to view only the ''Main Idea of the Passage' option then the matched yoked-controlled subject would be able to view only this assistance option for the specified passage. This procedure was applied to each of the matched subjects in the yoked-controlled group, and for all four passages.

The yoked-controlled group in this study was used in order to help answer the questions of whether perceived control of events would have an effect on; the attitude towards the computer experience, performance on an achievement test, and the amount of instructional time needed to complete the task. In order to answer these questions subjects in two groups, the learner-controlled group and the yoked-controlled group, were matched according to instructional strategies. The difference between these groups was that the learner-controlled group had the option to choose the strategy, while the yoked-controlled group was given the strategy used by his matched subject in the learner-controlled group, Therefore, the yoked-controlled group was used in an attempt to separate for analysis the effect of 'choice' from the 'strategy[1] employed. The use of the yoked-controlled group was used to determine if potential differences were caused by the learner-controlled group having the choice of options, or by the strategy used by the learners.

Four covariates were used in the study. The first and second covariates in the study were ability, which helped to determine if ability influenced achievement in completing learner, yoked, or program-controlled software. Ability was determined by the results of the Verbal and Nonverbal subtests of the Cognitive Skills Subtest of the Educational Development Series (EDS) battery of tests (Scholastic Testing Service, 1984).

The third covariate was the Age of the subjects at the time of testing, and the fourth was the personality characteristic of Locus of Causality (I) as measured on the attribution style test: The Intellectual Achievement Responsibility Questionnaire (IAR). The LAR questionnaire is aimed at assessing children's beliefs that they, rather than other people, are responsible for their intellectual-academic successes and failures.

Three dependent variables were used in the study. The dependent variables were performance on a post test which tested the reading comprehension of the subjects following their treatment, an attribution test which determined the subjects' causal beliefs about the computer situation, and the time taken to complete the designated task. The reading comprehension post test contained the same reading passages and questions as those provided by the software, with the exception that the latter was in a pencil and paper format. The attribution test was made up of questions that looked at four factors shown to be important to children in achievement situations: ability, effort, task difficulty, and luck, as they relate to the microcomputer experience. Questions were also asked about the enjoyment of certain aspects of the treatments .

The time required to complete all the passages was also measured to determine the efficiency of the three treatments. This was done by simply noting down the time taken for each subject to complete the four passages after all instructions were provided.

*Materials*

The computer program which was used in the study was a program called "The Comprehension Connection" created by Milliken Publishing Company (1987). The software package contains a management disk and five passage disks (El - E5). Each passage disk contains four reading passages which range in reading level from grade 4.6 through to 5.9.

The program used in this study provides students with a 150-300 word passage which students read. The student then utilize five assistance options in order to comprehend the passage, and answer five mu Itiple-choice questions. The split-half reliability estimate for the test items is reported to be. 86 as determined by Reinking (1988) using the Spearman-Brown formula. The assistance options provided by the software were:

- an easier, less technical version of the original passage;
- context-specific definitions of difficult vocabulary;
- the main idea of each paragraph in the passage;
- graphic aids associated with the content of the passage; and
- the opportunity to reread the passage.

These assistance options were either learner-controlled in which the student chose to use whichever options needed to understand the passage, or computer-controlled, where the student was forced to see, some of (yoked-controlled), or all (program-controlled) of the available assistance options in a certain order before attempting to answer the multiple-choice comprehension questions. A student could not change the type of control and had no access to the management disk which had this function.

The ability test used in this study was the Cognitive Skills subtest of the Educational Development Series (Level 15A) which is made up of a Verbal test and a Nonverbal test. The reliability measures of the Verbal test is reported to be .82 - .88 and .74 - .83 for the Nonverbal test (Scholastic Testing Service, 1984).

The attribution test used in the study was the IAR scale which is composed of 34 forced-choice items that describe either a positive or negative, hypothetical achievement experience followed by two alternatives; one that states an event was caused by the subject's own behavior, the other which states that an event was caused because of the behavior of someone in the child's environment (i.e., parents, teachers, peers). The IAR scale provides the researcher with three scores; the subject's belief in personal responsibility for success (I+), the subjects internal responsibility for failure (I-), and the total self-responsibility score (I) (! = !+ + I-). The test-retest reliability of the IAR is .47-.T4, and the internal consistency is .54-.60 (Stipek & Weisz, 1981, p. 105).

*Procedure*

The type of control the subject was provided with was preset with the use of a management disk. The pre-settingprocedure was quite simple. A management disk was provided with the software package which allowed the researcher to make an assignment for a subject based on the availability of the five assistance options. This was possible by choosing a 'yes' or 'no' for each of the options listed in the computer menu. If a 'yes' was provided for an option then the learner would be able to view that option, if a 'no' was provided the learner would not have access to that option. In creating the treatment for each of the groups, therefore, a 'yes'' was provided for all assistance options for the learner-controlled group and program-controlled group, while the yoked-controlled group was provided with some 'yes' and some 'no' options which followed a pattern established by the learner-controlled subjects.

Before the start of the study the grade five students were provided with parental permission slips. Subjects who had received written parental permission were randomly assigned to treatment groups, dismissed from their regularly scheduled classroom activities, and asked to complete the Cognitive Skills subtest of the Educational Development Series, and the IAR scale. The subjects completed the tests individually and the only assistance provided were the instructions for each of the tests. The instructions for the Cognitive Skills Test were provided with the test and were carefully followed. The instructions for the IAR scale were; ''Tick the answer that best describes what happens to you or how you feel." The subjects were told that there were no right or wrong answers on the IAR, and that responses for either test would not be given to anyone at the school.

After completing the tests, 7 subjects from different groups were brought down to the computer room and told to sit at a computer. When all students were seated, one student per computer, they were instructed how to use the computer program and told they had as much time as they needed to complete the four passages, and that they could begin. The students were required to read four passages, each of which was on a separate disk, view assistance options, and answer the multiple choice questions for each passage. Once the student had correctly completed the comprehension questions within the predefined parameters on one disk, the student requested the next passage disk and repeated the procedure. The researcher circulated around the computers helping with any computer problems that arose, and answered questions regarding the program, but refrained from answering any questions which pertained to the information presented by the software. After completing the four passages, the subjects returned to their classrooms, and another group of subjects were brought down to the computers. This procedure continued until all the subjects of one class had been exposed to the computer treatment. After approximately two hours students were then asked to complete a pencil and paper attribution test which determined their beliefs about the microcomputer experience, and a pencil and paper achievement post test. The procedure was then repeated with the next class and continued until all four classes were exposed to the treatment and tested.

## RESULTS

The cell means and standard deviations were calculated for the post test, verbal score, nonverbal score, age and time using SPSS-X and are reported in Table 1. The data were analyzed in three steps. First an analysis of covariance (ANCOVA) was conducted on post test scores. Three of the four covariates were found to be good predictors of achievement as measured on the post test: Verbal, $F(l,78) = 63.34, p < .05$; Nonverbal, $F(l,78) = 4.89, p < .05$; and Age, $F(l,78) = 4.60, p < .05$; while 'T' (Locus of Causality) was not a significant predictor of achievement, $F(l,78) = 2.59, p > .05$. A significant main effect for achievement as measured on the post test was found, $F(2,78) = 3.41, p < .05$ between learner control and program control, $F(2,78)=2.31, p < .05$. Homogeneity of regression was tested and was found not to have been violated. These results are illustrated in Table 2. No other significant differences in achievement between the program-controlled, learner-controlled, and yoked-controlled groups were found. Second an analysis of covariance on the time requ ired to complete the four passages found no significant difference between learner-controlled, program-controlled and yoked-controlled groups. Three of the four covariates were utilized and the results were: Verbal, $F(l,79) = 3.52, p > .05$; Nonverbal, $F(l,79) = .025, p > .05$; and Age, $F(l,79) = .029, p > .05$; while 'T' (Locus of Causality) which was not a significant predictor of achievement was not used. These results are illustrated in Table 3. Finally a one-way (ANOVA) between attribution and control found no significant differences.

TABLE 1
*Cell Means and Standard Deviations*

| Factor | Mean | SD | N |
|---|---|---|---|
| *Variable .. Post Test* | | | |
| Learner-Controlled | 13.76 | 3.897 | 29 |
| Program-Controlled | 16.07 | 3.463 | 27 |
| Yoked-Controlled | 14.86 | 3.739 | 29 |
| For Entire Sample | 14.87 | 3.785 | 85 |
| *Variable .. Verbal* | | | |
| Learner-Controlled | 26.66 | 9.370 | |
| Program-Controlled | 31.44 | 10.364 | |
| Yoked-Controlled | 29.38 | 9.966 | |
| For Entire Sample | 30.13 | 9.821 | |
| *Variable .. Nonverbal* | | | |
| Learner-Controlled | 33.45 | 8.588 | |
| Program-Controlled | 35.44 | 7.154 | |
| Yoked-Controlled | 35.90 | 8.789 | |
| For Entire Sample | 34.92 | 8.206 | |
| *Variable .. Age** | | | |
| Learner-Controlled | 10.61 | .551 | |
| Program-Controlled | 10.72 | .601 | |
| Yoked-Controlled | 10.73 | .457 | |
| For Entire Sample | 10.68 | .535 | |
| *Variable .. Time in Minutes* | | | |
| Learner-Controlled | 44.24 | 6.864 | |
| Program-Controlled | 42.56 | 8.126 | |
| Yoked-Controlled | 39.41 | 10.841 | |
| For Entire Sample | 42.06 | 8.914 | |

* Age is represented in years (i.e., 10) and the %-tage of months

## Discussion

The findings of this study do not support the hypothesized aptitude-treatment interaction between ability and control. Regardless of prior ability, the program-controlled group was superior in terms of performance when compared to the learner-controlled group. This finding suggests that all students benefit from program control regardless of ability.

The findings suggest that the significant difference in performance found between the learner and program-controlled groups was caused by the effectiveness of the strategy which consisted of viewing all assistance options in a predetermined sequence. The effectiveness of the designer's strategy is sup-

TABLE 2

*Analysis of Variance Post Test By Control with Verbal, Nonverbal, Age and I*

| Source of Variation | Sum of Square | DF Square | Mean | *F* | P |
|---|---|---|---|---|---|
| Covariates | 689.089 | 4 | 172.272 | 28.403 | <.01 |
| Verbal | 384.179 | 1 | 384.179 | 63.340 | <.01 |
| Nonverbal | 29.680 | 1 | 29.680 | 4.893 | <.05 |
| Age | 27.918 | 1 | 27.918 | 4.603 | <.05 |
| Locus of Causality | 15.725 | 1 | 15.725 | 2.593 | >.05 |
| Main Effects | 41.390 | 2 | 20.695 | 3.412 | <.05 |
| Control | 41.390 | 2 | 20.695 | 3.412 | <.05 |
| Explained | 730.479 | 6 | 121.747 | 20.072 | <.01 |
| Residual | 473.097 | 78 | 6.065 | | |
| Total | 1203.576 | 84 | 14.328 | | |

TABLE 3

*Analysis of Variance Time in Minutes by Control with Verbal, Nonverbal and Age*

| Source of Variation | Sum of Squares | DF Square | Mean | *F* | *P* |
|---|---|---|---|---|---|
| Covariates | 370.948 | 3 | 123.649 | 1.649 | >.05 |
| Verbal | 264.231 | 1 | 264.231 | 3.523 | >.05 |
| Nonverbal | 1.865 | 1 | 1.865 | .025 | >.05 |
| Age | 2.171 | 1 | 2.171 | .029 | >.05 |
| Main Effects | 378.837 | 2 | 189.418 | 2.526 | >.05 |
| Control | 378.837 | 2 | 189.418 | 2.526 | >.05 |
| Explained | 749.784 | 5 | 149.957 | 1.999 | >.05 |
| Residual | 5924.92 | 79 | 74.999 | | |
| Total | 6674.706 | 84 | 79.461 | | |

ported by the finding that there was a significant difference found between the program-controlled group which utilized the designer's strategy, and the learner-controlled group whose subjects utilized their own strategy. The effectiveness of designer's strategy is further supported by the means of the three groups in which the program-controlled group obtained the highest score (M =16.07), followed by theyoked-controlled group (M = 14.86) and then the learner-controlled group (M = 13.76). Though the difference between the program-controlled and yoked-

tL

controlled group was not significant, the trend in the means seems to suggest that utilizing the designer strategy is best in terms of performance.

To comprehend the information presented in the reading passages, readers needed to actively seek meaning from the text. The designer strategy may have been the most effective in developing active readers by encouraging them to monitor the degree to which they were understanding what they read, and applying these strategies to deal with any comprehension difficulties that arose. The options that were chosen by the designer to encourage active readers were supported by previous reading research (Milliken, 1987). Comprehension through vocabulary knowledge was encouraged by providing learners with a less technical version of the passage and an on-screen dictionary. Graphic aids were also used to encourage comprehension, and the presentation of the 'main idea' of the passage was used to help learners understand the passages by grasping the hierarchical relationships among ideas presented in the text (Kintsh & van Dijk, 1978). It appears that the assistance options, though powerful on their own, may complement on another as viewing all of them was most effective in helping students to comprehend the passages.

It also appears that perception of choice was not a fundamental factor in affecting performance as there was no significant difference found between the learner andyoked-controlled groups. As the only difference between these groups was the availability of choice, it appears that the perception of choice did not serve as a motivational factor. It also appears that having choice did not affect the learners motivation as measured on the attribution test as no difference was found for preference of the software program between groups.

The lower performance in the learner-controlled group may be because these young learners do not actively apply effective strategies when they are given control of instruction because they have not yet developed the cognitive skills required to make effective judgments. This conclusion is supported by Reinking and Schreiner (1985) who obtained similar findings, and concluded that perhaps younger learners are less adept at managing the contingencies of their reading and study and benefit from external control, in this case being forced to view all the assistance options instead of being given the choice of which options to choose.

These conclusions are also supported by Markham's (1977, 1979) research, which investigated elementary school children's comprehension, though without CAI. Markham concluded from her research with subjects in grade one through six, that children may be frequently misled into thinking that they understand information which in fact they fail to comprehend it.

This study may have implications for designers and users of educational software of this type with children. When attempting to promote reading comprehension there are many factors that could influence understanding, but the findings of this study suggest that providing young learners with a predetermined sequence to follow may be the most effective. Software designers, therefore, should not persist in providing software which is solely in the learner's control, but rather provide educationally sound versatile sequences which young learners should be encouraged to follow. In terms of classroom use of currently available educational software teachers should be versatile and sometimes suggest routes for students to follow through complex software, or provide guidance and direction to students when it is requested. It should be kept in mind, however, that the learning that is measured in this study is a low level cognitive skill on a reading comprehension software, and that further research should be conducted to determine if similar guidance should be provided with problem solving computer tasks or other software packages. Future research should also investigate how young learners react when provided with more control of the learning situation in terms of sequence, timing of presentation, and the many other dimensions of the learning situation.

Locus of Causality was not found to be a significant predictor of achievement as measured on the post test perhaps because very few students (5/85) were truly external. Locus of Causality may be affected by social class, in which researchers have stated that there is a lesser-belief in social-responsibility among lower-class children (Battle & Rotter, 1963). Though Crandall, Katkovsky, and Crandall (1965) claim that social class only accounts for a small proportion of the variance in IAR scores, other scales which look at locus of control, such as the Locus of Control Scale and the Children's Picture Test of Internality-Externality (Crandall et al., 1965), state that social class is indeed a contributing factor. The difference between these scales and the IAR, however, lies in the finding that the IAR looks at very specific social situations (i.e., school associated situations), while the other scales look at general social experiences, and this may account for the difference in the effect of social class.

If social class was not a contributing factor, or the only contributing factor, to the lack of external students in the sample, it may have been that the students were pulled towards the internal responses on the scale due to the responses social desirability. Crandall et al. (1965) tried to eliminate this "pull" by carefully wording the internal and external responses, and determining the lack of correlation between the IAR and the Children's Social Desirability (CSD) Questionnaire. A pull, however, may have been evident and contributed to the lack of external individuals being identified.

The findings further suggest that the amount of time to complete the task was independent of the type of control provided. This does not support previous research (Alpert & Bitzer, 1970; Fredericks, 1976) which suggests that program control is more time-consuming, but supports the findings reported by Lahey (1978) and Laheyetal. (1978). The three groups spent the most time viewing the Graphics option of the computer program, and the learner control group often chose to view this option more than once per passage.

One interesting question for further research would be to introduce the issue of advisement, giving learners meaningful information regarding their learning development while they are performing a task, in order to see if learners need information about the progress of their learning in order to effectively utilize the control they are provided with (Holmes et al., 1985; Tennyson, 1980; Johansen & Tennyson, 19^3; Tennyson & Buttrey, 1980). These researchers feel that simply providing control to the learner is not sufficient because learners often terminate the instruction too early, and make poor decisions. Providing advisement may help the learners utilize the control provided to them, thus helping to optimize the learning situation. The results of these studies utilizing advisement suggest that providing learners with information regarding their progress made towards mastering an objective helped learners both learn faster and use less instruction than learner control groups without this advisement. It is unknown whether similar findings would be found with younger learners as the bulk of this research has been carried out with older learners.

Another interesting direction for further study would be to investigate the assistance options chosen by subjects in the learner-controlled group in order to identify unnecessary options, as well as those options that were most frequently used or avoided by effective versus ineffective learners (Hannafin, 1984). It would also be interesting to note whether the options were consistently chosen or differed depending on the difficulty of the reading passage. This would help to identify effective and ineffective learning strategies as well as help plan future lessons.

In summary, this study found that regardless of the type of control provided, or the ability of the subjects, the best performance on the reading comprehension post test occurred when the designer's instructional strategy was utilized. Time to complete the task was independent of the type of control provided, and according to the attribution test data most students found the computer software to be very enjoyable to use.

Continued research in the area of computer-assisted instructional control is needed in order to more fully understand the effect of control and its influence on learners with different characteristics. Future studies may also introduce the issue of advisement, and instructional strategies and their impact on optimizing the learning situation.

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# Performance Support Systems: Guidelines for System Design and Integration

William D. Milheim

**Abstract:** With the Increasing availability of computer technology for a variety of job-related tasks, many organizations are turning to electronic performance support systems for the provision of information, decision-support, and training for on-the-job employees. The present article describes the components of thesesystems (advisory support, information base, learning experiences, and applications software) and provides suggestions for their design, development, and use,

Resume: L'usage grandissant des technologies electroniques dans les taches reliees au travail a amene un grand nombre d'organismes a se tourner vers les systemes de soutien Informatique pour l'apport d'information, le support decisionnel et la formation du personnel deja en poste. ['article qui suit decrit les elements constituants de ces systemes de support consultatif, de bases d'information, de program mes d'apprentissages et de logiciels d'application et offre des suggestions en ce qui a trait a leur conception, leur developpement et leur utilisation.

## INTRODUCTION

Over the past several decades, instructional technology has allowed educational institutions and corporate organizations to increase their efficiency and effectiveness through the use of well-designed instructional materials delivered in a variety of different media formats. In education, the focus for this utilization of technology has evolved from the use of large group media (film, videotape, etc.) to the implementation of individualized learning (computer-assisted instruction, slide-tape programs, etc.). In the corporate world, technology has traditionally been used as a support mechanism for stand-up training, typically involving videotapes and slide usage. These media are also changing in some companies to the use of more complex technologies such as interactive video and other forms of multimedia.

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Changes such as those described above are to be expected, since instructional technology itself has changed significantly over the past several years, through decreasing costs and increasing capabilities for many technological options. Computer-based training, for example, would not have been a possibility for many instructional tasks only ten years ago, simply due to the high costs and expertise required for its use. This situation has obviously changed radically within the last several years.

One of the most recent innovations in instructional technology involves the use of performance support tools, defined by Puterbaugh (1990c) as software designed to improve worker productivity by providing immediate, user-controlled access to integrated information, learning opportunities, and expert help. While such systems are not purely instructional by definition (because they may provide learning opportunities as only one component of their overall design), they do have the potential for making excellent use of available technologies and increasing user satisfaction and effectiveness on specific job tasks. Because system design is obviously of critical importance to its effective use, the present paper will focus on the appropriate design of these performance support tools.

*Rationale for the Use of Performance Support Systems*

In the past, traditional training programs have been used to provide knowledge, skills, and new information to employees working in a corporate environment. Training programs, while potentially effective, have proven to be somewhat inefficient because only a certain portion of what is taught in the classroom is actually remembered by the participants, with an even greater loss of information when a delay occurs between instruction and actual application on the job (Puterbaugh, 1990b). Training costs are also becoming prohibitive due to increasing costs for instructors, travel to and from training events (Courseware/Andersen Consulting, 1990), and lost employee work time for formal classroom sessions and complicated course structures (Horn, 1989).

The complexity of many of today's jobs also requires skills in numerous, inter-related content areas with over-lapping job responsibilities. While traditional training techniques can address each of these areas individually, it is difficult to design educational exercises that will simulate the actual, complex work environment as it will be viewed by employees as they perform their work assignments. In essence, it is difficult to provide employees with all the skills they will need in their work setting in advance of their actual placement in that environment.

A number of other problems related to employee access to information within an organization are described by Raybould (1990b). These include:

- problems accessing relevant information without being overloaded by non-relevant data;
- determining how to quickly find answers to specific questions;
- ensuring that users are accessing the most up-to-date information;
- allowing for different knowledge levels within users; and
- acquiring knowledge when needed, rather than in pre-scheduled training sessions.

Each of these areas can be particularly problematic when traditional training techniques are used in those organizations with large amounts of required or requested information.

The use of performance support, on the other hand, redefines how a company prepares and supports its employees' performance, by making resources and information available to people on-the-job instead of merely providing this data during off-the-job training sessions. Based on these requirements, such systems merge computer and information technologies to provide employees with training, reference, and expert advice on their own desktop computer terminals (Horn, 1989). These systems combine existing technologies with new performance models and allow the integration of learning experiences into the job itself, much like historical mentoring and apprenticeship programs (Puterbaugh, 1990b).

According to Wolman (1989), these tools allow the user to control the way that needed information is obtained (e.g., sequence, medium, level of explanation) and offer the spontaneity and individualization of on-the-job training or coaching without demanding another person's time. Gery (1989b) adds that such systems allow less experienced and knowledgeable people to be assigned more complex tasks, because the organization can leverage the knowledge of its experts to such personnel through this type of system.

In addition, performance support systems address potential problem areas including information overload, the need for easy access to information and training, geographic dispersion of employees, and the need for accurate, timely, up-to-date information (Raybould, 1990b). The use of performance support, however, requires a change in thinking from merely providing training events to the overall provision of information and support in the context of the job itself (Puterbaugh, 1990b).

While there is a strong rationale for the implementation of performance support systems, there are also significant barriers that must be overcome before employers and employees can take advantage of this new technology. Puterbaugh (1990b) lists a number of these barriers including:

- the small number of personnel in training organizations advocating new approaches or perspectives;
- the infancy of the performance support movement, which results in a lack of experienced practitioners, development models, procedures, and tools;
- difficulties comparing development costs for performance support tools with the benefits to be gained by their use;
- weak organizational links within an organization which may be insufficient to effectively assist in the design of a performance support tool;
- the lack of significant problems with the current state of affairs within training organizations; and
- the current methods typically used for measuring training output (number of student days spent in training or the number and diversity of various courses) — methodologies which do not fit performance support goals for minimizing the amount of time spent in learning situations.

Geiy (1989b) adds several other obstacles to the potential utilization of performance support systems. These include the probable shift of subject matter expertise from a person with the content knowledge to someone with both job knowledge and learner understanding as well as the lack of organizational reward for change.

Each of these barriers can, to some degree, inhibit the growth of performance support systems within a company or organization. However, knowledge concerning each factor and how it can potentially affect the design and use of such systems will assist the potential developer in obtaining company and employee support for the development process of these useful tools.

*Components of a Performance Support System*

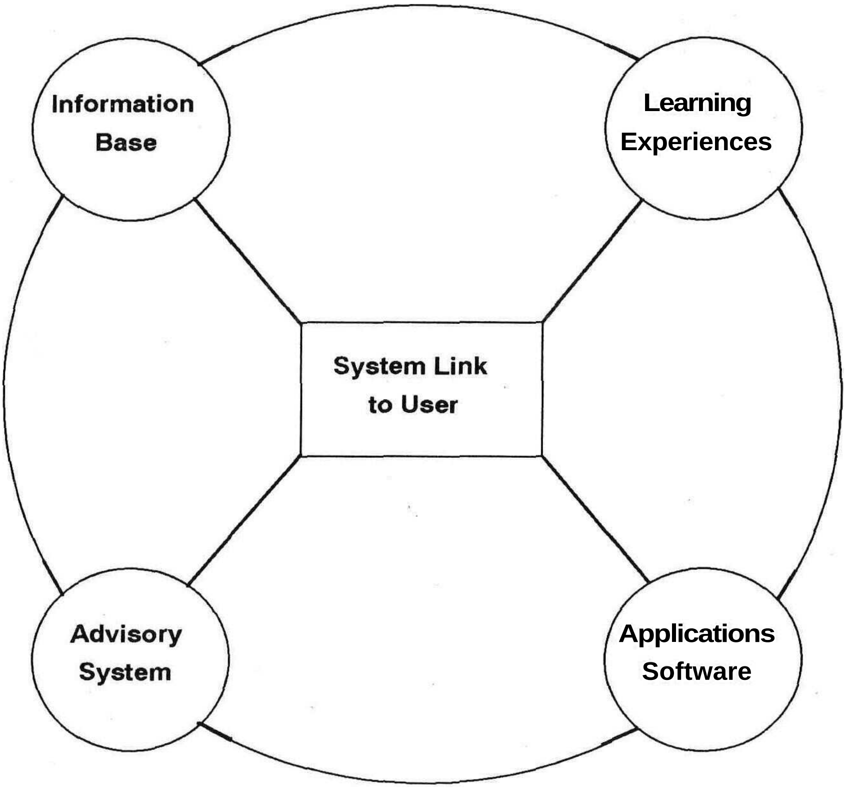
One of the most comprehensive definitions for a performance support system is stated by Gery (1989a, 1989b) who describes this type of system as an integrated, easily accessible environment structured to provide individualized access to information, software, guidance, advice, assistance, data, images, tools, assessment, and monitoring systems, which allow employees to perform their jobs with minimum of support from others. The Courseware/Andersen Consulting Company (1990) describes additional elements for a performance support system including systems reference, competency profiles, and company policies and procedures.

In general, such systems typically consist of three or four major components including: an advisory system to provide advice on task performance or decision-making, an information base that gives access to the information required to perform a certain job, learning experiences which can be linked to the information and advisory components whenever useful, and applications or productivity software, if available (Raybould, 1990b). Figure 1 provides a description for the design of a performance support system utilizing these components.

The advisory component of a performance support system is often composed of an expert system which assists the user in making decisions by asking questions and then providing recommendations based on rules that emulate human expert decision-making (Puterbaugh, 1990c). These "computerized experts" provide customized advice to each worker on demand and can include items such as troubleshooting, training path determinations (Courseware/ Andersen Consulting, 1990), assistance in problem structuring, and decision support analysis or diagnosis (Gery, 1989a).

This advisory component should be designed to take the place of a human coach or expert and should provide step-by-step assistance to the user, who may not have an in-depth understanding of the currently required task (Raybould, 1990b). As an intelligent job aid, this component can lead a user through an interactive session to solve a specific problem, while the computer keeps track of user responses and makes inferences based on its internal representation of the situation. Raybould (1990b) also suggests the use of multiple, small, task-specific expert systen; modules that can be linked to the document currently in use.

Figure 1.
*Performance Support System Design*




The second component, the information base, can be described as interactive documentation that includes the necessary information applicable to the performance support system, often structured in a hypertext or hypermedia format, which allows the user to navigate through the information in any order and to any depth (Puterbaugh, 1990c). This component can also include an on-line, field-specific help system; an integrated reference system organized around specific work requirements; and a section including system updates, system enhancements, new product announcements, etc. (Courseware/Andersen Consulting, 1990). Horn (1989) adds that such systems can also contain "company standard" knowledge (information and rules that have already been approved by the company) which allow employees to make quick decisions based on pre-approved knowledge.

Gery (1989a) describes this component as a data base that holds all the information that the user will need to use or manipulate in doing a job. She adds that this information can include:

- traditional data bases with numbers, libraries, and other data;
- text data bases including items such as procedures, policy and product information, specifications, business policy, glossaries, memos, and so forth;
- visual data bases with libraries of pictures, schematics, diagrams, graphics, maps, and full motion video;
- audio data bases with libraries of sounds and music; and
- information services such as the Dow Jones News Retrieval.

Each of these information formats would be of obvious assistance to employees based on the task being conducted at a particular time.

Since this type of data base can be quite large, retrieval techniques for locating information are very important. Raybould (1990a) describes two different methods to allow users to retrieve information from an electronic performance support system — query-based and browsing-based. According to Raybould, query-based techniques commonly include searching for text strings within the data base; however, this technique can have somewhat limited results because even expert users often find less than 80 percent of the available information, with other users experiencing "hit rates" as low as 20 percent.

The second type of information retrieval, browsing-based, can include retrieval types such as:

- associative retrieval (e.g., hypertext) which is particularly appropriate for ill-defined problems, exploring new task domains or for audiences with varying knowledge requirements;
- hierarchical outlines, similar to a book's table of contents, which can be useful for providing the user with an overview of the system; and
- manually-constructed indices, where connections among different information components may be different for each index.

In addition, Raybould suggests combining associative retrieval with other techniques when the information resides in very large, hypertext data bases.

The next component, the learning experience, also performs a valuable task within a performance support system through its ability to provide computer-based training "on-demand" while being tailored to the requirements of the worker's current or projected job (Courseware/Andersen Consulting, 1990). Raybould (1990b) suggests that this experience should focus on higher level learning skills such as problem-solving or simulations of the work environment, because facts and concepts are already present in the information base. Gery (1989a) adds that this component can be interactive and permit self-directed or structured learning experiences initiated by the performance support system or by the user.

Puterbaugh (1990a) provides several specific suggestions for the design of the computer-based training component within a performance support system including the elimination of elaborate conversational responses, the inclusion of a mouse interface for user control, and some means for proceeding without direct response by the user. Puterbaugh also suggests the provision of an escape route at any point from the computer-based training portion of the system and not requiring a separate sign-in for this section.

Assessment procedures may also be designed into the training component of a performance support system to permit the evaluation of knowledge or skills either before or after actual task performance (Gery, 1989a). These procedures can take the form of test questions, case problems, or simulations, which permit the user to determine whether certain knowledge or skills have been acquired (Puterbaugh, 1990a).

The fourth component, applications or productivity software, could include word processing programs, spreadsheets, data bases (Courseware/Andersen Consulting, 1990), communications packages, desktop publishing programs, or other software needed by the user in the course of a normal workday. Each of these applications should be readily accessible, with data easily exchanged among the various software packages. In addition, the control structure for each program should be similar, so that valuable training time will not be wasted while the user learns how to use each software package.

*Integrated Component Design*

While each of these components is critical to the overall effectiveness of a performance support system, it is the interface between components and the links to the user which provide the employee with the tools to display information, advice, etc. Without appropriate integration, the system will not be able to quickly or easily provide the required assistance to the person requesting system support.

Overall, each component should be available whenever needed in the form required by each user request. There should be a consistent, easy-to-use system interface within each module (Gery, 1989a), allowing the employee to move almost effortlessly between each component, querying the system as desired. The use of this type of interface should allow users to utilize more components within the system while improving productivity and reducing training time for new applications or software packages (Raybould, 1990a).

In addition, each component should be context-linked to every other component with easy access between each module, similar in some ways to the integrated modules available in some types of computer software which link information from one module to another. With this type of interface, the system almost "knows" what is being searched for when a request is made (Puterbaugh, 1990c).

With this emphasis on ease of use, the integration of the system components should be based on the least experienced user's knowledge and mental abilities (Gery, 1989a), while still being helpful to even the most experienced user. While this wide range of potential users will cause some difficulty during the design and development of a performance support system, it will make the package useful for all employees whose tasks are supported by the system.

The integration of these components is also described by Horn (1989), who provides the following guidelines for this process:

- the provision of a common interface between all components to reduce navigation problems and optimize access times,
- direct access by the user to any topic or task regardless of context, and
- support for multiple levels of assistance depending on the experience level of the user and the current problem.

*Development and Distribution of Performance Support Systems*

Gery (1989a) describes a relational data base structure as the most powerful tool for developing a performance support system, while less powerful forms include software indexing systems (e.g., on-line reference systems), information structuring tools (e.g., HyperCard), hierarchical databases, and software implemented through programming languages. Raybould (1990a) also describes several potential development tools including text management and retrieval systems, computer-based reference systems, electronic documentation systems, hypertext systems, knowledge processors, expert system shells, CBT authoring languages, and user interface environments. The exact choice of a software tool to be used in the development process, however, should be based on the specific needs for the performance support system in a particular environment within an organization.

Raybould (1990b) lists several other design considerations for building a performance support system including:

- which platform technology to use;
- which distribution media to use (magnetic or optical);
- which distribution network to use (centralized or local);
- how to successfully integrate several different technologies and platforms into a single system;
- how to assist users in finding information quickly, easily, and completely; and
- how best to organize the information.

Based on these questions, Raybould (1990a) makes the following recommendations for distributing the finalized, performance support system to potential users:

- If the information life cycle is less than 3 months, distribute the system on magnetic media.
- If the volume of information is less than a few megabytes, use diskettes.
- If the /olume of information is larger than a few megabytes and the life-cycle is relatively short, a network solution may be appropriate.

- If the life-cycle is relatively long and the volume of information is quite large, CD-ROM may be appropriate.
- If the information is relatively static over time, the information can be published on CD-ROM with updates distributed on magnetic disks or posted on electronic bulletin boards.

*Future Potential for Performance Support Systems*

According to (Gery, 1989a), performance support tools will see widespread adoption in the foreseeable future due to the availability of the technology, the explosion of creativity in methods for using this technology, and the inadequacy of training as it is currently conducted in organizations today. In addition, current methodologies cannot improve employee performance quickly enough to meet the changingbusiness conditions of current and future organizations. While performance support tools do not replace all training requirements within an organization, they can be quite effective at increasing employee productivity during the performance of required, work-related tasks.

However, the use of any technological system within an organization requires a careful analysis of needs, current systems, and projected requirements to be effective. This information, in conjunction with a better understanding of knowledge support systems and their potential for employee assistance, will help to increase the adoption ofsuch systems, where appropriate, and reduce the need for traditional training that may not be appropriate or cost effective.

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# Canadian Journal of Educational Communication

# Index to Volume 21

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