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 l'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 l'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 l'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;

Canadian Journal of Educational Communication. VOL. 2], NO. 3. PAGES 207 -221. ISSN 0710-4340

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 and guiding 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, thenurse 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 wh ich wou Id 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 presentedforstudents to study ormodel(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 th is 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.

REFERENCES

Abelson,R. (1981). Psychological status of the script concept. *American Psychologist, 36(1),* 715-729.

Adams, L., Kasserman, J., Yearwood, A., Perfetto, G., Bransford, J., & Franks, J. (1986). The effects of fact versus problem-oriented acquisition. Unpublished manuscript, Vanderbilt University, Nashvill, TN.

Alfaro, R. (1986). *Application of nursing process: A step-by-step guide.* Philadelphia: Lippincott.

Anderson, J.R. (1990). *Cognitive psychology and its implications.* San Francisco: W.H. Freeman.

Anderson, R., & Pichert, J. (1978). Recall of previously unrecallable information following a shift in perspective. *Journal of Verbal Language Learning and Verbal Behavior, 17,* 1-12.

Anderson, R., Reynolds, R., Schallert, D., & Goetz, E. (1977). In A. Lesgold, J. Pelligrino, S. Folkema, & R. Glaser (Eds.), *Cognitive psychology and instruction.* New York: Plenum Press.

Benner, P. (1987). *From novice to expert — Excellence and power in clinical nursing practice.* Menlo Park, CA: Addison Wesley Publishing Co.

Bower, G., Black, J., & Turner, T. (1979). Scripts in memory for text. *Cognitive Psychology, 11,* 177-220.

Bransford, J., Franks, J., Vye, N., & Sherwood, R. (1986). *New approaches to instruction: Because wisdom can't be told.* Paper presented at a conference on Similarity & Analogy, University of Illinois, June.

Bransford, J., & Johnson, M. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior, 11,* 717-726.

Bransford, J., Sherwood, R. S., Hasselbring, T. S., Kinzer, C.K., & Williams, S. M. (in press). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. Spiro (Eds.), *Advances in computer-video technology.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Bransford, J., Sherwood, R. S., Vye, N., & Reiser, J. (1986). Teaching thinking and problem solving. *American Psychologist, 41(10),* 1078-1089.

Bransford, J.,Vye,N.J.,Adams,L.T.,&Perfetto,G.A. (1989). Learningskillsand the acquisition of knowledge. In A. Lesgold & R. Glaser (Eds.) *Foundations for a psychology of education.* Hillsdale, N.J.: LEA.

Brewer, W., & Treyens, J. (1981). Role of schemata in memory for places. *Cognitive Psychology, 13,* 207-230.

Brewer, W., & Nakamura, G. (1984). The nature and functions of schemas. In R. Wyer & T. Srull (Eds.), *Handbook of social cognition.* Hillsdale, NJ: Lawrence Erlbaum.

Brown, A., Bransford, J., Ferrara, R, & Campione, J. (1983). Learning, remembering and understanding. In J. Flavell & E. Markman (Eds.), *Carmichael's manual of child psychology (Vol. 1).* New York: Wiley.

Chi, M., Feltovich, P., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5,* 121-152.

Cognition and Technology Group at Vanderbilt (1992). Anchored instruction in science and mathematics: Theoretical basis, developmental projects and initial findings. In R. Duschl and R. Hamilton (Eds.) *Philosophy of science, cognitive psychology and educational theory and practice.* Albany, NY: SUNY Press.

Cognition and Technology Group at Vanderbilt (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19(6), 2* -10.

Curtis, K. (1988). How to help your students think! *Clinical Education Outlook, 1,*1-2.

Dalton, D. W. (1986). The efficacy of computer-assisted video instruction on rule learning and attitudes. *Journal of 'Computer-Based Instruction, 13(4),* 122-125.

Derry, S. (1990). Learning strategies for acquiring useful knowledge. In B. F. Jones & L. Idol (Eds.) *Dimensions of thinking and cognitive instruction.* Hillsdale, N.J.:LEA.

Dick, W. 0., & Carey, L. (1990). *The systematic design of instruction.* Glenview, IL: Scott, Foresman & Co.

Dooling, D., & Lachman, R. (1971). Effects of comprehension on retention of prose. *Journal of Experimental Psychology, 88,* 216-222.

Dooling, D., & Mullet, R. (1973). Locus of thematic effects in retention of prose. *Journal of Experimental Psychology, 97,* 404-406.

Dunn C. (1983). The influence of instructional methods on concept learning. *Science Education, 67,* 647-656.

Egan, D.E., & Schwartz, B.J. (1979). Chunking in recall of symbolic drawings. *Memory and Cognition, 7,* 149-158.

Gick, M., & Holyoak, K. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 12,* 306-355.

Harless, W. G. (1986). An interactive videodisc drama: The case of Frank Hall. *Journal of Computer-Eased Instruction, 13(4),* 113-116.

Henderson, V. (1982). The nursing process. *The Journal of Advanced Nursing 7,* 103.

Jonassen, D. (1988). *Prototype development and acquisition in an interactive video concept leson.* Presented at annual meeting of the Association for Educational Communication and Technology, New Orleans, LA.

Jonassen, D. (1988b). *Instructional designs for microcomputer courseware.* Hillsdale, NJ: Lawrence Erlbaum.

Kintsch, W., & Greene, E. (1978). The role of culture-specific schemata in the comprehension and recall of stories. *Discourse Processes, 1,* 1-13.

Kuzma, D. (1989). Script schemas. In J. Canelos (Ed.), *AECT-RTD Newsletter, 13* (2), 63-71.

McCloskey, M., & Glucksberg, S. (1978). Natural categories: Well-defined or fuzzy sets? *Memory and Cognition, 6,* 462-472.

McNamara, T. P., Miller, D. L. & Bransford, J. D. (in press). Mental models and reading comprehlension. In T.D. Pearson, R. Bair, M. Kamill and P Mosenthal (Eds.). *Handbook of reading research 2*. New York: Longman.

Merrill, M.D., Li, Zhongmin, & Jones, M.K (1990). Second generation instructional design (ID2) *Educational Technology, 30(2),* 7-14.

Nitsch, K.F. (1977). Structuring decontexualized forms of knowledge. Unpublished doctoral dissertation. Vanderbilt University, Nashville, TN.

Norman, D. (1988). *The psychology of everyday things.* New York: Basic Books.

O'Day, E., Kulhavy, R., Anderson, W., & Malczynski, R. (1971). *Programmed instruction: Techniques and trends.* New York: Appleton, Century, Crofts.

park, O. (1984). Example comparison strategy versus attribute identification strategy in concept learning. *American Educational Research Journal, 21,* 145-162.

pichert, J., & Anderson, R. (1977). Taking different perspectives on a story. *Journal of Educational Psychology, 69,* 309-315.

Jlosch, E. (1978). Principles of categorization. In E. Rosch & B. Lloyd (Eds.), *Cognition and categorization.* Hillsdale, NJ: Lawrence Erlbaum.

Jlumelhart, D.E. (1980). Schemata: The building blocks of cognition. In R. Spiro, B. Bertram & W. Brewer (Eds.), *Theoretical issues in reading comprehension.* Hillsdale, NJ: Lawrence Erlbaum.

Jlumelhart, D.E., & Norman, D.A. (1981). Analogical processes in learning. In J.R. Anderson (Ed.) *Cognitive skills and their acquisition.* Hillsdale, NJ: Lawrence Erlbaum.

Sherwood, R., Kinser, C., Bransford, J., & Franks, J. (1987). Some benefits of creating macro-context for science instruction: Initial findings. *Journal of Research in Science Teaching, 24(5),* 417-435.

Shiffrin, R.M. &Dumais, S.T. (1981). The development of automaticism. In J.R. Anderson (Ed.) *Cognitive skills and their acquisition.* Hillsdale, N.J.: Lawrence Earlbaum Associates,

gjmon, J., & Hayes, J. (1977). Psychological differences among problem isomorphs. In M. Castelan, D. Pisoni, & G. Potts (Eds.), *Cognitive theory,* (Vol. 2). Hillsdale, NJ: Lawrence Erlbaum.

Stein, B. (1978). Depth of processing re-examined: The effects of the precision of encoding and test appropriateness. *Journal of Verbal Learning and Verbal Behavior, 17,* 155-174.

fpennyson, R. D. (1990). Integrated instructional design theory: Advancements from cognitive science and instructional technology. *Educational Technology, 30(1),* 9-15.

Tennyson, R. D., & Cocchiarella, M. (1986). An empirically based instructional design theory for teaching concepts. *Review of Educational Research, 56,*40-71.

Tennyson, R.D., & Rasch, M. (1988). Linking cognitive learning theory to instructional prescriptions. *Instructional Science,* 77,369-385.

Tennyson, R. D., Youngers, J., & Suebsonthi, P. (1983). Acquisition of mathematics concepts by children using prototype and skill development presentation forms. *Journal of Educational Psychology,* 75,280-291.

Thorndyke, P. (1977). Cognitive structures in comprehension and memory for narrative discourse. *Cognitive Psychology, 9,* 77-110.

Thorndyke, P., & Hayes-Roth, F. (1979). The use of schemata in the acquisition and transfer of knowledge. *Cognitive Psychology, 11,* 82-106.

Thorndyke, P. (1984). *Application of schema theory in cognitive research. Tutorials in learning and memory.* In J.R. Anderson & S.M. Kosslyn (Eds.). San Francisco: W.H. Freeman, Co.

Walker, J. (1975) Real-world variability, reasonableness judgments and memory representations for concepts. *Journal of Verbal Learning and Verbal Behavior, 14,* 241-252.

Wolf, J. (1986). Group decision making: Teaching the process—An introductory guided design project. *Journal of Nursing Education, 25,* 388-389.

Yoho,R. (1986). Effectivenessoffourconceptteachingstrategiesonsocialstudies concept acquisition and retention. *Theory and Research in Social Education, 14(3),* 211-223.

Yura, H., & Walsh, M. (1988). *The nursing process* (5th ed.). Norwalk, CN: Appleton & Lang.

NOTES

'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.

AUTHORS

Richard Hamilton is Associate Professor in the Department of Educational Psychology, University of Houston, 4800 Calhoun Road, Houston, TX 77204-5874.

C. David Taylor is Instructional Designer (Information Systems R&D), Educational Technologies, LRC, Old Security Bldg., Blacksburg, VA 24061-0232.