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Presenting Questions, Processing Responses, and Providing Feedback in CAI

Walter Wager
and
Susan Wager
Department of Educational Research,
Development and Foundations
307 Stone Building
Florida State University
Tallahassee, Florida 32306

Abstract. There are two general categories of guidelines for presenting questions, processing responses and processing feedback in CAI: those related to proper and effective use of the computer medium (formatting guidelines), and those related to principles derived from learning theories and research (psychological guidelines). Presently, most CAI authoring guides deal primarily with formatting guidelines which embrace one overriding principle: make the computer as unobtrusive and easy to use as possible so as to avoid student confusion and frustration.

Formatting guidelines are certainly important and necessary, but not sufficient to guide the development of effective instructional software. In addition, instructional developers must focus on those guidelines which are based on current research and learning theories. This paper discusses some of the research on learning as it relates to the use of questions, response processing, and feedback in CAI.

Educators and psychologists in the 1950's and 1960's actively engaged in the process of research and development of programmed instruction (PI). The work of the pioneers in the field of PI gave us a new technology of instruction that began with behavioral analysis, continued with materials development, and ended with empirical validation. This technology created much promise for changing the nature of instruction, and it generated a large volume of research on learning from programmed materials.

Today, the computer has replaced the programmed text and designers of computer-assisted instruction (CAI) are offering many criteria for developing "good" CAI in the form of guidelines for authors (MECC, 1981; CDC, 1977; Peters, H. & Johnson J.W., 1978; UD, 1981). Most of these guidelines address "formatting concerns" or problems specific to using the computer as an instructional delivery device. While guidelines concerning the format of material to be presented with a computer are important, they are insufficient to guide the development of effective CAI.

This leads us to ask what principles of PI might be applicable to CAI. Likewise, what other guidelines (derived from current research, experience, and common sense) might serve as "heuristics" for the design of CAI? This paper surveys the research on PI, questions, and feedback in instruction, in order to identify those guidelines which are derived from learning theories or based on empirical data.

Active Learner

One of the primary assumptions of PI was that the learner must actively participate in the learning process. He or she made responses to instructional stimuli, and practiced those responses until they were learned and retained. This called for the frequent presentation of questions as an integral part of the instruction. Holland (1965) states,

A major difference between programmed instruction and nonprogrammed material is that programmed instruction increases the probability of a correct answer, while nonprogrammed material in normal textbooks or in pseudoprograms is not directly related to an answer by the student, either because no answer is required or because the material is extraneous as far as the response is concerned (p. 84).

Programmed instruction, as conceptualized by B.F. Skinner (1958), presented the learner with a series of short "frames" of information. Each frame included a question covering the information in that frame. The learner wrote a response to the question and then checked it for accuracy. Feedback confirmed the correct response, and was thought to "reinforce" the response, thereby increasing the probability that it would be elicited again under similar stimulus conditions. The program was designed so that almost all members of the target audience would be able to answer the questions in the program successfully. All students saw the same frames and answered the same questions. Because a learner moved in a linear fashion through the sequence of frames, these programs became known as "linear programs".

In Skinner's linear programs, the student's response behavior was equated with learning. Instruction was based on the behavioral principle of successive approximation to a goal. Consequently, the "terminal behavior" was broken down into small component behaviors. As a student worked through a program, he was queried for each response that comprised the terminal behavior. The program made extensive use of prompts and practice frames to insure learner success. As the program progressed, prompts were "faded" (made less obvious and decreased in frequency) until the learner could successfully perform the terminal skill without them. These programs effectively taught the skills they purported to teach, but were also long, tedious, and overly instructive for faster students.

Another approach to PI involved the presentation of information in larger chunks, followed by a multiple choice question. If the student answered the question correctly, she would advance to the next main-track frame. If she answered it incorrectly, the program "branched" to a remedial frame or a
series of correction frames. Here her incorrect response was redisplayed, she was told why it was wrong, and then she was branched back to the original question frame. This type of PI, developed by Norman Crowder (1960), became known as 'intrinsic programming'. The underlying principle of intrinsic programming was that the student's choice of an answer to a multiple choice question determined the material that the student worked through next. The purpose of questions and feedback was to allow the student to check her understanding of the material, so she could correct misconceptions before continuing with the program.

Obviously, the purpose of questions in PI was to engage the learner in the learning process, to make him or her an active participant. Yet we can see that Skinner and Crowder differed in their beliefs about how instruction should be designed to maximize learning. The two approaches varied with respect to the amount of information presented in a frame of instruction, the type of responses elicited, and the nature of the feedback. The empirical data indicate that both approaches were effective, though perhaps for different reasons.

The Use of Questions in Instruction

While many principles of behavioristic psychology are still valid for the design of CAL, most instructional research today is based on an information processing model developed by Shiffrin and Atkinson in 1969. This model proposed a multi-step process of learning that included sensory registers, short-term memory, control processes and long term memory. Theoretically, information travels from the sensory register to short-term memory, where it then may be encoded either verbally, or as an image, and transferred to long term storage. The role of questions in facilitating information processing has been studied by many researchers, and summarized by Anderson (1970), Frase (1970), Gall (1970), Kumar (1971), Bull (1973) and Ladas (1973). We conclude, from these reviews, that questions serve three general functions in learning: (a) To establish and maintain attention, (b) to facilitate encoding, and (c) to provide for rehearsal.

Establishing and Maintaining Attention

The short-term memory has a limited processing capacity, so the student must selectively scan new material in order to limit incoming information (Kumar, 1971). Anderson (1970) calls this "cue selection" or "selective attention". He notes that "people selectively attend to the strongest, most salient, most meaningful or most discriminable aspect of a compound stimulus" (p. 350). Gagne (1985) feels that this is one of the roles served by behavioral objectives: They focus the learner's attention on relevant information in the instructional presentation. Studies by Rothkopf and Bisbicos (1967), Frase, Bruning and others (cited by Anderson, 1970) show that questions which precede instruction also serve to focus the learner's attention on important information. When questions were used in this fashion, students tended to score less well on tests covering incidental information (information not directly related to the questions). Material without affecting the students' ability to answer correctly. Holland concluded that these programs were so heavily prompted that they allowed the students to answer questions without having to attend to the requisite information.

Anderson, Faust and Roderick (1968) further studied the effects of prompting by adding prompts to a PI program. They found that students working through a heavily prompted program finished faster and made fewer errors than students in a nonprompted condition, but they learned less than the students in the less prompted condition. Anderson claims that this occurred because the students didn't need to learn the material to respond.

The ability of the student to find short-cuts is one of the major reasons Anderson (1970) feels that the early PI

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Formatting guidelines are certainly important and necessary, but not sufficient to guide the development of effective instructional software.

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Kumar (1971) feels that this inattention to incidental information is an "economy move" on the part of the processing system as the short-term memory is capable of holding only from five to nine pieces of information in storage at one time. Thus, when new information enters the short-term memory, existing information must be encoded into long-term storage, chunked with other information, or it is lost.

Another attention device used in conjunction with questions are prompts. Prompts help students respond correctly to a question by focusing attention on relevant stimuli and are of two varieties: (a) Formal, such as spaced blanks in questions denoting the length of the answer, or (b) thematic, contextual or grammatical cues (Markle, 1969). However, prompts can be overused.

In a study of PI programs, Holland (1965) used a "black-out" technique to eliminate program material that was not relevant to answering questions. He found that, in some cases, it was possible to delete up to 68 percent of the research was inconclusive in many respects. Much of the PI materials used in research gave students the opportunity to see the answer before they studied the frame. Later queried, these students admitted to copying the answer when it wasn't obvious to them. This copying of the answers "shortcuts" the learning process, and thus the student learns less.

Facilitating Encoding

Information theorists believe that in order to be remembered, information must be encoded and moved from short-term memory to long-term memory. Anderson (1970) states that after noticing the stimulus, the student must encode it in some meaningful manner, either auditorily or semantically. Auditory encoding takes place when the learner "verbalizes" the stimulus. After verbalization, the student may then semantically encode the stimulus by translating the verbalization into an image. Anderson notes that research indicates that words which evoke visual images are remembered longer than
Questions serve to establish and maintain attention, to facilitate encoding, and to provide for rehearsal.

Much debate has taken place in PI as to whether the student must respond overtly or whether it is sufficient to respond covertly ("think" the answer). Similar debate focuses on whether a constructed response or selected response (multiple choice) question format is more effective in facilitating learning. With regard to attentional properties of the question, it makes little difference whether the answer is overt or covert (assuming the material read is used in making the response), or whether the question is fill-in or multiple choice. However, with regard to coding (moving the information into long term storage, the effect of overt responding is to encode the material auditorially. This is not to say that covert responding isn't effective (when the student actually does it)! However, it is easy to short-cut, i.e., continue with the material without actually answering the questions. With regard to question type, Holland (1965) suggests that the nature of the learning task should determine the response form: "When the criterion task requires a specific response topography, such as writing a new Spanish word, constructed response seems to be the better form. If recognition is desired the evidence to support this contention. He claims that recall of information aided by post-questions is greater for those at the end of the material, because of the nature of short-term memory. Material at the end of a passage stays in short-term memory longer because it is not displaced by new information. Questions in this position within the passage tend to evoke a "reency effect" that Kumar attributes to rehearsal. To the extent that questions serve a rehearsal function, they will facilitate learning.

Guidelines
Using Questions
The following guidelines for using questions in CAI have been derived from the preceding research.
• When using questions as an attention device (before the text) remember that pre-questions will focus attention on information related to answering the questions, to the detriment of incidental learning.
• Order material from simple to complex, building on what the student already knows.
• Be careful when using prompts to ensure that the learner has to process the information in the display in order to answer the question.
• Remove prompts as the program progresses until the learner is making the complete desired response without prompts.

These guidelines are based on both behavioristic principles of successive approximation to a goal, and cognitive principles relating to the role of attention and encoding. Prompts facilitate correct responding by cueing the learner as he enters the answer. However, prompts should be faded as the instruction progresses, thereby encouraging the learner to recall successively greater amounts of material. Holland (1965) states that, "The answer required should be one (the student) can give if, and only if, the appropriate preparatory behavior has occurred (p. 78)."
• If a small number of answer options are available for a question, use a multiple choice format to prevent frustration arising from poor spelling and/or poor keyboard skills (MECC, 1981).
• If the criterion test requires a specific response topology, constructed response is the better form.

These two guidelines seem somewhat contradictory because they attend to different concerns. The first is a formatting concern while the second is a consideration derived from learning theory. Research on the relative effectiveness in promoting learning of constructed response vs. multiple choice response is inconclusive. Holland (1965) states, the proper choice of question type is probably best determined by the nature of the learning task. If recognition is desired, the response form is probably unimportant.

One reason for utilizing multiple choice questions is that the problem of response judging is much easier. At present, natural language processing by the computer is very limited. This constraint makes it difficult to allow a student to phrase an answer "in her own words." So, for the most part, a constructed answer must be checked for an exact match or a key-word match.
this stage in its development.

- Use "fill-in-the-blank" questions to reduce response ambiguity and show the answer in context. (MECC, 1981)

It is possible that using fill-in-the-blank type of questions and showing the answer in context may help the learner visualize the stimulus response relationship and increase the long-term association between the stimulus and the response.

- Place the question after the text passage or diagram to which it refers to facilitate retention.

Research on adjunct questions shows that questions presented after the text increases the learning of question relevant material, probably due to a rehearsal effect (Kumar, 1971). However, according to Ladas (1973), there is no evidence that adjunct questions placed after the text increases the learning of incidental material.

- When the student must select options or refer to a graphic, keep necessary information on the screen or allow "toggling" between the information and the question (MECC, 1981).

- When using an illustration in a question frame, require that the student refer to the illustration in order to answer the question.

It is often impossible to fit all the necessary instructional information on a single screen. Often it is more practical for the teacher to provide supplementary paper-based materials with the essential diagram or chart. PI research suggests that when an illustration or diagram is used it should be accompanied by a question testing whether or not the learner understands what it represents (Markle, 1966).


Computer programmers often try to make up for limited space on a the screen by using abbreviations. However, any abbreviation or cryptic message increases the chance that a learner will attach an inappropriate meaning to information which may be encoded and remembered.

- Inform the learner of special conditions and expectatios of performance.

The learner should know how many tries he will have on a question, and the scoring rules (if any). He should also be told if the response is to be timed, for he may choose to use a different search strategy than if it is untimed.

- Provide enough practice. Practicing beyond the point of mastery can substantially reduce forgetting (Peters, H. & Johnson J.W., 1978).

- Provide for spaced review after initial mastery (CDC, 1977).

- When feasible, repeat the questions the student missed on the first try later in the lesson (MECC, 1981).

Authors' knowledge, untested. The role of question type in CAI is largely an unexplored issue in need of empirical research.

- When using exact match answer judging routines, anticipate the types of input and provide for alternate correct answers, anticipated wrong answers, and inanticipated answers.

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Prompts help students respond correctly to a question by focusing attention on relevant stimuli.

These last three guidelines relate to several principles derived from PI, and current research on information processing. They seem to address the functions of rehearsal and coding by having the learner respond in a variety of contexts (in association with a number of relevant stimuli). Spaced review helps in maintaining the retrieval strength of the newly learned associations.

**Response Processing**

After a student makes a response, she must be given some indication of the correctness of her behavior. In order for this to occur on the computer, her response must be "processed" or compared to a predetermined answer to see if it matches. Because of the computer's limitation in discriminating correct answers, the CAI developer must give the student the widest possible latitude in response entry so that an answer is not judged incorrectly. Most of the guidelines related to input and response judging are based on this consideration.

Many educators are concerned that CAI limits what can be taught because the computer is unable to evaluate higher order questions (analysis or synthesis type questions). Actually, these limitations are related to natural language processing, and not to question type. As mentioned previously, it is possible to pose higher order questions and models of acceptable answers against which students can judge the adequacy of their responses. The effectiveness of this technique is, to the

This guideline acknowledges that there are many ways that a constructed response may be entered (e.g., G. Washington, George Washington, Washington, WASHINGTON, etc. in response to the question, "Who was the first president of the U.S.?"). An exact match must anticipate acceptable variations in input. One way to decrease the probability of incorrect input is to use multiple choice questions (it is very difficult to anticipate all possible incorrect answers to constructed response type questions).

- When feasible, use a keyword match to process a response (MECC, 1981).

- Consider partial response checking (a combination of an anticipated response and a key word) for constructed response items (MECC, 1981).

- Remove all leading and trailing blanks, also collapse multiple consecutive blanks into single blanks before continuing input processing (Peters, H. & Johnson J.W., 1978).

- Use spelling algorithms, arithmetic parameters, and capitalization and punctuation removal routines when available, and when the behavior being taught does not require an exact response (CDC, 1977; MECC, 1981; Peters, H. & Johnson, J.W., 1978).

The above formatting guidelines address the exact match problem. A key word search looks for a letter or set of letters within the answer and is accomplished by a process called string parsing. The student's response (string) is "taken-
apart” (parsed) to see if a key letter or word(s) are present. If so, the response is judged as correct. A problem arises in that too liberal of a test will judge incorrect answers as correct, while too strict of a test will fail to recognize correct answers. The third guideline above is an attempt to improve the processing of exact match items by removing extra spaces that the learner may inadvertently enter. Response processing algorithms that increase the flexibility of response judging are built into many of today’s CAI languages.

- Restrict the number of tries allowed before presenting the learner with the correct answer or corrective feedback (CDC, 1977).
- On a two-choice question, don’t give the learner more than one try since the answer is obvious if he gets it wrong (MECC, 1981).
- Make sure that the student has an “out” other than RESET, regardless of the correctness of his answers, or else give the correct answer after a reasonable number (2 or 3) of attempts (CDC, 1977).
- Provide the learner with a list of available program options (e.g., 1-BACK, RETURN-FORWARD, 2-HELP, 3-QUIT).

Some of these formatting guidelines, found in authoring guides, are at odds with the findings of research. For instance, Suppes and Ginsberg (1962) found that overt correction may result in faster learning. Children using multiple choice questions that were required to pick the correct option after making a mistake learned faster than those who were not. Also, the help option in the program has to be carefully constructed so as not to “overprompt” the learner’s response.

- Ensure that the learner must make a substantive response before being shown the answer.
- The learner should not be allowed to simply press the RETURN key as a response to a question. However, it is doubtful that having the learner merely copy the correct response from a feedback message is helpful.

Feedback

Feedback is any message or display that the computer presents to the learner after a response. This communication between computer and learner may be as simple as “yes” or “no” (knowledge of results) or “answer C is correct” (knowledge of correct response). Or, it may be an elaborate explanation of why the student’s answer is incorrect and how to find the correct answer (elaborated feedback). Finally, feedback may be a statement of praise, an animated graphic, or an auditory signal that is used to indicate the correctness/incorrectness of a particular response.

Acquisition of the correct answer when the learner sees feedback. Superior long-term retention results when the learner is given some time to forget his incorrect answers before he views feedback. Properly used linear prompting and fading strategies also avoid incorrect answer “interference” problems.

Semantic encoding may be facilitated by the use of questions in instructional material.

Feedback serves two functions during instruction: it motivates the learner, and it provides information as to the correctness of the learner’s responses. The motivational aspects of feedback are highly personal and variable among learners, and will not be discussed in depth here. We will focus primarily on corrective feedback, or information which directly addresses specific student responses.

Informative feedback functions in one of two ways upon a response: (a) It informs the learner that the response is accurate, or correct, and (b) it corrects her if the response is wrong or allows her to correct herself. This iterative process of confirmation and correction is the essence of incremental learning. The correction aspect of feedback is its most important function, and has the greatest effect on learning. The research on the confirmation of correct responses is inconclusive, but it has never been shown to be harmful. In fact, it has been shown to facilitate learning in 40 percent of the studies (Holland, 1965).

There is widespread acceptance that feedback must be immediate to be effective, and that delayed feedback is ineffective, even detrimental to the learning process. This is simply not the case in many instances. A review of the research with academic materials (Wager, 1982) generally indicates that during acquisition of a skill, immediate and delayed informative feedback are equally effective in promoting learning. With respect to long-term retention, however, delayed feedback produces better retention than immediate feedback. Most researchers believe that initial error responses interfere with the acquisition of the correct answer when the learner sees feedback. Superior long-term retention results when the learner is given some time to forget his incorrect answers before he views feedback. Properly used linear prompting and fading strategies also avoid incorrect answer “interference” problems.

Despite the acknowledged importance of feedback in the learning process, the effects of form of feedback on learning and retention is still largely unclear. It seems logical to suppose that the more information that the learner has about his response, the greater will be his understanding and therefore, overall learning. However, after more than a decade of research, there is no definitive information about how feedback form or content affects learning (Kulhavy, 1977).

The purpose of these introductory statements is to make clear from the onset that there are few guidelines for the development of feedback in CAI that are substantiated by sound empirical data. Many guidelines for developing instructional feedback are merely “heuristics,” based upon the best practical knowledge and experience of instructional designers, teachers, and computer users. Whatever their origin, the following guidelines are grouped into three categories: (a) general considerations, (b) feedback after correct answers, and (c) feedback after incorrect answers.

General Considerations

- Effective feedback is response specific; it provides information directed specifically at a learner’s errors, so that she has the opportunity to correct her misconceptions.
- Avoid feedback that is misleading or ambiguous.
- Informative feedback has its greatest effect after a wrong response. Feedback should focus on correcting the misconception represented by the particular answer choice, or provide the information necessary for the learner to correct this misconception. Anticipating com-
common errors and creating appropriate feedback and remedial sequences to address them should facilitate learning.

- On an exact match type of question, anticipate types of student input and provide for alternative correct responses.

When using exact match answer judging routines, don’t penalize and frustrate students who know the correct answer to a question, but don’t know how to input it. Anticipate alternative correct responses to accommodate input variations, as well as errors in spelling or capitalization. If abbreviations are acceptable, but not preferred, for example, indicate this in the feedback or directions.

- Use the student’s name in the feedback.

This attention technique hasn’t been shown to increase learning, but students do seem to like it, and it’s easy to program.

- Generally place feedback on the screen below the input and near it so that it is noticeable to the learner.

The rationale for this guideline is that learners generally expect feedback to appear after the question, so that’s where they look for it to appear on the screen. Close proximity of the feedback to a response makes comparison with the question quicker and easier, perhaps strengthening the stimulus-response connection. This guideline is based upon experience and common sense rather than on research.

- Keep the question, student’s response, and feedback in view at the same time.

- Draw attention to feedback by pointing to or underlining relevant parts of both question and response.

The question, response, and feedback should appear together on the screen if the learner is to understand and correct his misconceptions about significant content. Highlighting techniques help the learner focus on the critical attributes of the feedback or the relationship between the question and response, and thereby increase retention.

- Avoid reward that is time-consuming.

Finishing an instructional sequence is in itself rewarding, so that elaborate “reinforcement” is usually unnecessary. Graphics and sound are frequently distractors to both the student and others around him (Friend and Milojkovic, 1984).

- Provide summary feedback over a series or pattern of responses.

Informing a learner that he got 5 out of 7 responses correct on a particular practice is appropriate, constructive feedback. It may supplement, or in some cases replace (as in a drill), response specific feedback. Statements like, “On more than half of the questions in this practice, you added instead of multiplied” are useful in helping a learner correct specific patterns of errors.

Feedback After Correct Responses

- If a response is correct, give only a short affirmation as feedback.

Students generally know they are correct, and simple acknowledgment of that fact is sufficient. Elaborate feedback after correct responses is not only unnecessary, but slows the pace of the instruction.

Despite the acknowledged importance of feedback in the learning process, the effects of form of feedback on learning is still largely unclear.

- When possible, reinforce the correct answer by placing it in the sentence or problem.

Responses should be displayed within in the context of the item when possible. According to information processing theory, seeing the correct response within the context of a sentence or a problem may enhance long term retention.

- Provide feedback for answers that are partially correct; include information that helps students format their answer correctly.

Although there is no empirical research to support this guideline it makes sense in terms of formatting considerations. A tutor would probe a student’s partially correct answer in order to “shape it” into a completely correct answer. Feedback routines that tell students why their answer is partially correct or incomplete help to shape a correct response.

Feedback After Wrong Responses

- Provide feedback for anticipated wrong responses that tells learners precisely why their answer is incorrect.

Since feedback is most effective after a wrong response, this guideline is especially important. Simple, direct corrective feedback after a wrong response does much more to correct misconceptions than a “blanket” type of message which is displayed after all errors. A simple “No, you’re wrong,” or “No, try again” doesn’t offer much guidance in correcting an error. Programmers should purposely utilize multiple choice questions in order to limit possible responses and provide corrective feedback for each incorrect alternative.

- Avoid wrong answer feedback that is entertaining or novel.

Entertaining graphics, or humorous or novel comments presented as feedback for errors often become reinforcing in the sense that students will purposely make wrong responses just to see the entertainment! There is some evidence that students do learn wrong associations from selection type questions (Holland, 1965). Entertaining feedback might possibly strengthen this effect.

- Provide increasingly informative feedback after each successive wrong answer (Alessi & Trollip, 1985).

The empirical support for this guideline is unclear. It seems that additional information might serve as remediation and is essentially no different that what was being proposed by intrinsic programmed instruction. However, the focus is not on why the response was wrong, but rather on providing additional cues or information. This would be an interesting area for further study.

Summary

PI research and information processing theory provide us with a number of guidelines for developing CAI. Most important seem to be those related to the
use of questions as attention, coding and rehearsal devices, and those related to corrective feedback. Further research should be done to test the validity of many of these guidelines, and to develop an expanded and stronger base for the design of CAI.

During the acquisition of a skill, immediate and delayed informative feedback are equally effective in promoting learning.

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JOURNAL OF INSTRUCTIONAL DEVELOPMENT
Designing Practice: A Review of Prescriptions and Recommendations from Instructional Design Theories

David F. Salisbury  
Center for Educational Technology  
406 EDU  
Florida State University  
Tallahassee, FL 32306

Boyd F. Richards  
Office of Educational Research  
Bowman Gray School of Medicine  
Winston-Salem, NC 27013

James D. Klein  
Department of Educational Research, Development, and Foundations  
Florida State University  
Tallahassee, FL 32306

Abstract. Most instructional theories offer some unique and valuable suggestions related to the design of practice activities. However, no single theory or model is available which provides instructional designers with answers to many basic questions related to designing practice activities. The purpose of this paper is to summarize the strategies and suggestions offered by various prominent instructional theories and thereby provide a useful guide for designing the practice component of instruction.

Various instructional theories include recommendations for designing practice activities for different types of learning tasks. Each theory offers some unique and valuable suggestions related to the design of practice activities. However, no single theory or model is available which provides the answers to many of the basic questions instructional designers frequently encounter in designing the practice component of instruction such as: "How much practice is required for skills which will later serve as subskills to more complex skills?" "Should separate skills be practiced separately or should they be practiced together?" "Where should help be used during practice?" "When should practice items be selected at random?" In order to aid instructional designers in answering these questions, a more useful and complete guide is needed. The purpose of this paper is to summarize the somewhat piecemeal strategies and recommendations included in various prominent instructional theories and thereby provide a useful guide for designing the practice component of instruction.

It might be appropriate to state why such a focus on the practice component of instruction is needed. One reason comes from research in modern cognitive learning theory which suggests that in order to perform complex intellectual tasks such as reading, computing, or computer programming, many of the subskills involved have to be automated so that attention can be devoted to the more intricate and complicated aspects of the total task (Anderson, 1980). Certain critical subskills must not only be mastered but must, through practice, be brought to a state of automaticity. Research in areas such as reading and mathematical problem solving suggests that one reason students have difficulty performing higher order cognitive skills is due to a lack of automatic performance of the underlying subskills (Legold, 1983; Legold & Resnick, 1982; Resnick & Ford, 1981).

Another reason to concentrate on practice stems from the increased use of computer-based training. Microcomputers allow designers to incorporate into practice strategies psychological techniques and procedures beyond what might otherwise be possible. However, designers still need some guidance in selecting the appropriate instructional techniques for various types of computer-based practice activities.

A third reason is the current use of authoring systems or templates for the design of CAI. Generally, the various authoring systems that have been developed offer only one strategy for practice while most instructional design theories prescribe different practice activities for different types of learning tasks. For this reason, several authors have recommended the development of more specialized templates for authoring. To quote Merrill (1981): "The use of templates would be more acceptable if a variety of templates were provided for the different types of learning" (p. 10). An integration of the various strategies and prescriptions provided by instructional design theories is needed in order to design authoring templates for specialized types of practice activities.

Some theorists have made the observation that there is already a great deal of scientific knowledge about learning and cognition and what is needed now is a synthesis of those areas of knowledge which are most likely to increase the quality of instructional products (Reigeluth, 1983; Reigeluth, 1985; Gerlach, 1984). Conceivably, this synthesis would result in prescriptive models or generalizable rules which would guide the behavior of instructional designers. This paper attempts to provide such a synthesis in the area of designing practice. It is also hoped that this work will stimulate the formulation of other syntheses.

Rationale for Selection of Theories

Theories which provide the most pertinent information for the design of practice have been selected for review. There are many good instructional models which are not included because they concern themselves primarily with course development or large-scale curriculum or program development and do not provide recommendations for the design of the practice component of individual lessons.
The motivational design model of Keller (1983) was included because motivation is important in the design of practice and because it is relatively neglected in other instructional theories. While some of the theories regard motivation as an important element of instruction, none provide any concrete strategies for enhancing motivation.

**Recommendations for the Design of Practice Activities Derived from Behaviorism**

Behaviorism is concerned with those factors in learning that are external in nature. The behaviorist is interested in predicting and controlling behavior through reinforcement. In a behavioral approach, the learner is presented with a stimulus, and a response is made. The response is then reinforced. When a stimulus is presented repeatedly, and the appropriate response to it is made, the response is said to be under the control of that stimulus. Establishing stimulus control depends upon two conditions: active practice of the correct response; and, reinforcement of the response following its practice.

One might view the behaviorist theory as a collection of general principles and concepts which govern the acquisition of a skill. George Gropper has done a great deal of work in integrating the general principles of behaviorism into concrete prescriptions for designing instruction (Gropper, 1973, 1974, 1975, 1983). Gropper identifies six "tools" which instructional designers can apply directly to specific instructional tasks. In essence, these tools are components of the learning environment which can be varied to increase or decrease the demands put on students at any stage in a practice progression. *Early practice* sessions are designed to place less demand on students; *intermediate practice* sessions increase demands on students in one or more ways, and *final practice sessions* require students to perform the skill in criterion mode. The six tools are:

1. The amount of cueing that is provided for a practice task,
2. The size of the unit of behavior that is practiced in a practice task,
3. The mode of stimulus and response that is required in a practice task,
4. The variety that is built into a practice task,
5. The type of content involved, and
6. The frequency with which a task is practiced.

The designer uses these tools to systematically vary the practice so that *early*, *intermediate*, and *final practice* differs in one or more of these six ways. For example, in early practice, cues are provided, in intermediate practice fewer cues are provided, and in final practice no cues are provided. Gropper’s model shows how to vary practice sessions using the six tools in order to increase the demand placed upon students in the three stages of practice. Gropper provides prescriptions involving cue strength, behavior unit size, stimulus and response modes, practice example variety, content of practice, and frequency of practice.

Gropper also provides suggestions for organizing practice activities and matching practice activities to objectives. The following table summarizes his recommendations for five types of learning objectives.

**Recommendations for the Design of Practice Derived From the Work of Gagne and Briggs**

According to Gagne (1984, 1985), learning tasks can be classified into five categories: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. The learning (and consequently the practice) within one category is different in important respects from the learning (and practice) in the other four categories.

Gagne and Briggs (1979) outline nine *events of instruction* which facilitate the five different types of learning. Because different conditions are required for different learning outcomes, the nature of the events of instruction also differs for each type of learning outcome. The Gagne and Briggs theory also includes some guidelines for selecting instructional media. The nine events prescribed by Gagne and Briggs are shown in Table 2.

According to this formulation, practice is defined as the portion of instruction which takes place after students have initially been presented the information needed to perform an objective (events 1-5) but before they have had an opportunity to master it. This definition of practice views practice as what student do after having been guided through the material and before being tested on it (event 8). If the students fail the test, they should then receive more practice (more of events 6 and 7). Enhancing retention and transfer is also accomplished in part through the practice component of instruction.

Some of the guidelines for selecting media coming from the theory are also applicable to the design of practice activities. Briggs defines instructional media as all methods used to present stimuli to students. In this sense, media include not only audiovisual materials, but also include the teacher and other activities. Briggs recommends that media be selected separately for each instructional event depending on what conditions are necessary to present that event. Based on this idea, media for the practice component of instruction would not necessarily be the same as the media needed for the practice component of instruction.
<table>
<thead>
<tr>
<th>Type of Learning</th>
<th>Initial Practice</th>
<th>Intermediate Practice</th>
<th>Final Practice</th>
</tr>
</thead>
</table>
| Learning Facts   | • Tell students the facts they are to learn.  
                  • Provide cues to highlight the facts when a number of facts are to be learned at one time (e.g., a table of basic multiplication facts highlighting pairs of numbers and their products).  
                  • Require practice of only a few facts at a time. | • Have students apply the facts as well as state them (e.g., using the basic multiplication facts).  
                  • Fade cues used in initial practice.  
                  • Increase number of facts practiced. | • Have students apply all facts when possible. No longer require students to state the facts.  
                  • Eliminate all cues.  
                  • Have students practice the total criterion behavior (e.g., all multiplication facts are practiced in a random order). |
| Defining Concepts | • Define concept and ask students to state it.  
                  • Use cues to differentiate between instances and non-instances.  
                  • Have students classify instances.  
                  • Use concrete objects in early practice when possible. | • Continue to give instances and non-instances but make them more difficult to differentiate.  
                  • Have students generate some instances.  
                  • Still ask students to state definition.  
                  • Gradually make instances more abstract. | • Require students to state definition, and classify or generate instances without cues.  
                  • Make practice abstract, verbal, or symbolic. |
| Giving Explanations | • Provide students with the explanation and require them to practice stating it.  
                   • Provide specialized cues (like flowcharts and demonstrations) to help students relate multiple concepts.  
                   • Give examples and non-examples of the explanation. | • Continue giving examples and non-examples but gradually make them more difficult.  
                   • Require students to produce their own explanations in their own words in addition to giving the model explanation.  
                   • Gradually fade cues. | • Have students state the explanation in their own terms without the use of cues.  
                   • Require students to use the concept being explained instead of just giving the explanation (e.g., using the principle of reinforcement, not just stating it). |
| Following Procedural Rules | • Provide students with the steps for following the procedure or give a demonstration of the procedure.  
                             • Require students to practice the steps in the procedure.  
                             • Break down long or difficult procedures into smaller units and practice the individual units (e.g., learning to drive may start with learning the rules of the road before getting behind the wheel.) | • Continue practice of the individual steps in the procedure.  
                             • Add additional steps to long or difficult procedural chains. | • Require students to practice the procedure in full with no breaks in the chain. |
| Solving Problems | • Give students the rules needed to solve the problem.  
                  • Require students to distinguish correct answers from incorrect ones.  
                  • Break up difficult or long problems into smaller units and practice the individual units (e.g., solving long division problems is practiced step by step.) | • Give students a problem with a wrong answer and ask them to correct it. (Practice moves from the recognition phase to the editing phase)  
                  • Require students to generate their own rules for solving a problem. | • Require students to solve the problem with no help. (Practice moves into the production phase).  
                  • Ask students to generate their own solutions when possible (e.g., answering long division has a fixed procedure, and unique solutions may not be found). Other problem solving can be unique. |
### Table 2
Instructional Events

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting the stimulus material
5. Providing learning guidance
6. Eliciting the performance
7. Providing feedback about performance correctness
8. Enhancing retention and transfer

### Table 3
Practice Activities for Different Types of Learning

<table>
<thead>
<tr>
<th>Learning Outcome/ SubCategory</th>
<th>Eliciting the Performance</th>
<th>Providing Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intellectual Skills Discriminations</td>
<td>Provide a variety of items which require students to show that they see two or more objects as different objects by responding to their names.</td>
<td>Indicate if response was correct or incorrect. For multiple discriminations also give correct response.</td>
</tr>
<tr>
<td>Concrete Concepts</td>
<td>Provide a variety of items which require students to point to two or more instances of the concept. The instances should differ as widely as possible in their non-evaluable or characteristics.</td>
<td>Refer to properties present or not present in instances.</td>
</tr>
<tr>
<td>Defined Concepts</td>
<td>Provide a variety of items which require students to identify the referents of the words which make up the definition and show their relationship to one another.</td>
<td>Refer to the parts of the demonstration which were incorrect and tell why they were incorrect.</td>
</tr>
<tr>
<td>Rule Using</td>
<td>Provide a variety of items which require application of the rule.</td>
<td>Refer back to rule and show how correctly or incorrectly applied.</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Provide a variety of problems for solutions.</td>
<td>Change stimulus situation in response to learner's action and/or state the rule being followed or violated at each response.</td>
</tr>
</tbody>
</table>

#### 9 Verbal Information

<table>
<thead>
<tr>
<th>Facts</th>
<th>Ask student to state each fact verbally.</th>
<th>Identify what is wrong or omitted from the statement of the fact.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Names/Labels</td>
<td>Ask student to provide the name-label for each object.</td>
<td>Identify what is wrong or omitted in the name-label.</td>
</tr>
<tr>
<td>Connected Discourse</td>
<td>Ask student to state the material verbatim.</td>
<td>Identify errors and state correct version.</td>
</tr>
<tr>
<td>Organized Knowledge</td>
<td>Ask student to state proposition in own words.</td>
<td>Identify what is wrong or omitted from the statement of the proposition.</td>
</tr>
</tbody>
</table>
used to present the other events of instruction. Also, the selection of media for the practice of a skill will depend upon the type of learning outcome involved.

Table 3 outlines the recommendations for eliciting responses and providing feedback for two kinds of learning: intellectual skills and verbal information. Note that the stimuli and the feedback differ for each subcategory in the two learning categories.

**Component Display Theory and the Design of Practice**

According to the Component Display Theory (Merrill, Richards, Schmidt, & Wood, 1977; Merrill & Tennyson, 1977; Merrill, 1983), instruction to teach cognitive subject matter consists of a series of presentations that convey information or ask questions. These presentations, or instructional building blocks, can be described using five partially independent taxonomies. These taxonomies and their categories are as follows:

1. **Type of content**: Facts, concepts, procedures, and principles (rules).
2. **Level of Performance**: remember (recall, recognize), use (classify, demonstrates), and find (discover, deduce, derive).
3. **Abstractness of Subject Matter**: generalities (definitions, list of steps) and instances (examples, specific cases).
4. **Presentation Mode**: expository (tell, illustrate) and inquisitorily (question).
5. **Presentation Form**: primary presentations (generalities, examples, practice), secondary presentations (elaborations, helps, mnemonics, feedback), process displays (advice about how to learn), and procedural displays (instructions about how to use delivery media).

This theory specifies the types of presentation (the mix of the 5 taxonomies) to include for effective instruction. Practice consists of inquisitory (4) primary presentation forms (5) that require students to demonstrate knowledge of generalities or instances (3) at any level of performance (2) and for any type of content (1).

The relationships among the 5 taxonomies can best be seen using three 2-way matrices. The first matrix (Figure 1) combines performance level and type of content. All practice activities in a subject area can be classified into one of the 10 cells of the matrix. Sample practice questions from a variety of subject areas are included in each cell as an illustration.

According to the component display theory, learning is most likely to occur when instruction properly uses primary and secondary presentation forms. Primary presentation forms deal with the essence of the objective to be learned. Secondary forms add to that essence such things as cues, background information, advice about learning and feedback. Primary and secondary forms can be presented together (as an integrated display) or separately.

There are four types of primary presentation forms that can be made by crossing abstractness of subject matter with presentation mode. Figure 2 contains this abstractness-mode matrix with a sample primary presentation in each cell. Practice is represented by the inquisitorily column.

There are eight types of secondary presentations. Use of each type depends upon the context, performance level, abstractness, and mode of the primary form with which it is associated. For example, a secondary presentation for an expository generality about a complex concept could be brief definitions of sub-concepts. The most important secondary presentations for practice are feedback and alternate representation of questions. Component display theory prescribes the minimum set of primary and secondary presentations for each performance level and for each presentation mode. Figure 3 presents a brief summary of these presentations. Practice again is represented in the inquisitorial column.

Component display theory provides numerous guidelines regarding the quality and quantity of practice. Seven guidelines are summarized below.

1. **Make practice activities** (inquisitorious presentations) **consistent** with the type of content and performance level specified in the objective.
2. **Require a use or find level of performance as much as possible.**

<table>
<thead>
<tr>
<th>FIND</th>
<th>USE</th>
<th>REMEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sort these rocks into piles. Tell how somebody would sort them into the same piles later.</td>
<td>Demonstrate how to clean a clarinet.</td>
<td>What is the value of pi?</td>
</tr>
<tr>
<td>Write a computer program that will index and retrieve recipes.</td>
<td>Demonstrate how to clean a clarinet.</td>
<td>Define positive reinforcement.</td>
</tr>
<tr>
<td>Set up a demonstration that will help show how water gets into a well.</td>
<td>Explain why one of the two boats is much lower in the water than the other.</td>
<td>What are the steps in balancing a checkbook?</td>
</tr>
</tbody>
</table>

**Figure 1. Performance-Type of Content Matrix.**

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**Figure 2. Abstraction-mode matrix.**

<table>
<thead>
<tr>
<th>EXPOSITORY (TELL)</th>
<th>INQUISTITORY (QUESTION)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENERALITY</strong></td>
<td></td>
</tr>
<tr>
<td>A square is a closed figure with 4 equal sides.</td>
<td>Give the definition of a square.</td>
</tr>
<tr>
<td><strong>INSTANCE</strong></td>
<td></td>
</tr>
<tr>
<td>Here is a square:</td>
<td>Is this a square?</td>
</tr>
</tbody>
</table>

**Figure 3: Minimum prescriptions for primary and secondary presentation forms.**

<table>
<thead>
<tr>
<th>EXPOSITORY MODE</th>
<th>INQUISTITORY MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIND</strong></td>
<td></td>
</tr>
</tbody>
</table>
| PPF: 1) State definition, list of steps or principle.  
2) Illustrate generality with several examples.  
SPF: Give background info, review prerequisites and include attention focusing cues as necessary. | PPF: Give several problems.  
SPF: 2) Vary representation of problem and do not repeat them.  
2) Provide feedback that includes why an answer is right or wrong. |
| **USE**         |                   |
| PPF: Give facts, concept, procedure or principle or example of them depending upon which is to be memorized. | PPF: 1) Ask for exact recall.  
2) Require recognition of an exact duplicate.  
SPF: Indicate with feedback if recall or recognition was correct. |
| **VERBATIM**    |                   |
| PPF: Give fact, concept, procedure of principle and one example. | PPF: 1) Ask for a paraphrased recall.  
2) Require recognition of different representation of the same thing.  
SPF: Indicate with feedback if recall or recognition was correct. |
| **REMEMBER**    |                   |
| **PARAPHRASE**  |                   |

*primary presentation form  
*secondary presentation form
3. Embellish primary practice forms with secondary presentations, especially feedback. Match the feedback to the level of performances and type of content.

4. Systematically vary non-relevant attributes of instances; make the set of instances as diverse as possible.

5. Gradually increase the difficulty of the practice.

6. Clearly separate and identify practice presentations from other primary and secondary presentations.

7. In many circumstances, give students freedom to choose the number of practice presentation forms in the overall instructional sequence.

**Recommendations for the Design of Practice Derived from Cognitive Research**

There are several issues arising from recent research in cognitive learning theory which are not incorporated per se in any instructional theory. This section summarizes these issues and their implications for designing practice.

**Automaticity**

One important issue relevant to the design of practice activities which is not discussed in any of the instructional theories reviewed is the issue of automaticity. Automaticity refers to the state at which a skill ceases to consume much of the attentional capacity of the brain. This means that an automated skill can be performed simultaneously with other tasks without interfering with the performance of those tasks. People commonly automate skills such as typing, discriminating numbers from letters, or decoding common words.

Current research suggests that the performance of complex skills such as reading, computer programming, or mathematical problem solving requires that many of the subprocesses become automatized (Anderson, 1980). It is not sufficient that these subprocesses be performed correctly—they must be brought to a state of automaticity or the performance of higher-level tasks is impaired (Lesgold, 1983; Lesgold & Resnick, 1982; Resnick & Ford, 1981).

Practice drills intended to promote automaticity include three stages. The first stage helps the student learn to perform the skill accurately. The second stage introduces speeded practice and continues until performance is both fast and accurate. The third stage requires students to attend to a competing task while continuing to perform the original task until performance becomes fast, accurate, and automatic.

**Interference**

Most instructional theories emphasize how to teach a single fact, concept, rule, or procedure. They do not give specific recommendations on how to design practice for many facts, concepts, rules, or procedures. Consequently, these theories do not thoroughly consider the issue of interference.

**Spacing of Practice Sessions**

There is much evidence in the literature to suggest that short, spaced periods of practice give better results than long concentrated practice periods (Anderson, 1980). Studies on the effects of spacing have shown that the pro-

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In order to perform complex intellectual skills such as reading, computing, or computer programming, many of the subskills involved have to be automatized.

Interference occurs in practice activities involving many similar items. Interference occurs when students confuse one stimulus-response association with other stimulus-response associations. One type of interference, where new associations interfere with old ones, is referred to as retroactive interference. Another type of interference, where old associations interfere with the formation of new ones, is referred to as proactive interference. Both kinds of interference increase with the number of items to be practiced. Consequently, special considerations must be made for designing practice involving voluminous subject matter.

Designers can reduce the amount of interference present in a practice exercise by following a few simple guidelines:

1. Rather than having students work on all of the content at once, have them practice a small subset of the content. By practicing on a small subset of the content, the amount of interference is reduced. Group the content to be practiced into subgroups to be practiced separately, or introduce new material progressively as old material is mastered.

2. Since the strength of an association is weakened by the learning of new associations, review old items or material as new material is introduced.

3. Compare and contrast similar practice items with special cues so that the student can observe and note the differences. This is particularly useful when items are initially presented in a drill. As the drill progresses, eliminate the cues completely.

This evidence suggests that practice activities should be designed so that students can stop in the middle of a practice session or drill and then resume at a later time picking up the same items or material that they were working on during the previous session. In some cases, this can be done by dividing the content into difficulty levels and allowing the students to specify the appropriate difficulty level at the beginning of each new session. In other cases this requires that
a record be kept of student performance from session to session. This record would contain the data necessary to allow students to restart the practice or drill using the items or material that they were working on during the previous session.

Spacing of Review Sessions

Spaced review has been shown to be a significant means of enhancing retention of learned material. For example, Tiedeman (1946) found that after two spaced reviews students retained for 63 days the same amount of information they would have retained for only one day without the reviews. Gay (1973) demonstrated the superiority of an early and late review over two early or two late reviews. Other studies have shown these same superior effects for spaced review over massed review (Ausubel & Yousef, 1965; Hannum, 1973; Peterson, Ellis, Toohill, & Kloss, 1935; Saxon, 1981).

The research on spaced review suggests that designers should provide for several reviews of mastered material and that each successive review be spaced farther apart than the previous review. This can be done by setting up a series of review stages allowing mastered material to be reviewed at different stages, say after a day, then after two days, then after a week, then after ten days, etc. Practice drills should provide increasing-ratio review where the ratio of new items to review items changes as students progress through the drill. When students first begin the drill all items will be new items. As students master items, these become review items and are re-introduced systematically. Toward the end of the drill most of the items presented to the students will be review items. Drills structured in this way can be very effective for the purpose of skill maintenance in addition to initial learning.

Making Meaningless Material More Meaningful

There is much evidence to indicate that people remember meaning and relationships rather than exact details. For example, Wanner (1968) had students listen to tape-recorded instructions and then, in a test, compare several alternative sets of instructions with the one they heard. Results showed that students could identify word changes which resulted in changes of meaning, but could not identify word changes which resulted only in changes of style. The same point has been demonstrated in experiments which have contrasted memory for meaningful sentences with that of memory for random word strings revealing that people remember the meaning rather than the exact wording of a verbal communication (e.g. Pompi & Lachman, 1967).

The superiority of memory for meaning over memory for details is accounted for by the idea of propositional representation which is currently one of the most popular concepts of how material is represented in memory. According to this conception, material is stored in memory in the form of propositions which include only the meaningful parts of an event or learning task and do not include details considered to be unimportant (Anderson, 1976). Students tend to exclude from their propositional representations material

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Table 4
Recommendations for the Design of Practice Derived from Cognitive Research

<table>
<thead>
<tr>
<th>Issues</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automaticity of subskills</td>
<td>In addition to accuracy, speed and the ability to perform the skill without interfering with a secondary task should be used as criteria for mastery.</td>
</tr>
<tr>
<td>Interference</td>
<td>Have students drill on only a small subset of items at a time. Provide review of old items as new ones are introduced. Initially use cues to emphasize differences among competing stimuli and then fade the cues gradually.</td>
</tr>
<tr>
<td>Spaced Practice</td>
<td>Allow students to specify the difficulty level at the beginning of each session or provide a mechanism to keep track of the items that a particular learner was working on during the last session.</td>
</tr>
<tr>
<td>Spaced Review</td>
<td>Gradually increase spacing between practice of mastered items. Utilize increasing ratio-review.</td>
</tr>
<tr>
<td>Making Meaningless</td>
<td>Help students add meaning to the material by utilizing mnemonic devices, mediators, or other memory or organizational strategies, or emphasize networks inherent in the content.</td>
</tr>
<tr>
<td>Information</td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td></td>
</tr>
</tbody>
</table>
specifically focuses on this aspect of instruction—how to make instruction more motivating and engaging for students. Keller's model draws together knowledge from various theoretical perspectives into a set of prescriptions for making instruction more motivating and engaging. As defined by Keller (in press), "motivational design is an aspect of instructional design which refers specifically to strategies, principles, and processes for making instruction appealing." Motivational design adds another dimension to the traditional idea of instructional design. Instructional design shows us what instruction should be like

The objective of a good practice drill should be to convert a learning task which does not have much inherent meaning into something more meaningful.
should include strategies to enhance the learner's confidence. This can be done by:
- Clearly stating the expected performance and evaluation standards of a practice activity
- Structuring practice material so it is presented in identifiable units in nature rather than contradictory. Many of the guidelines derived from one theory are supported by several of the other theories. Different terms are often used to refer to the same phenomenon in different theories which tends to make the knowledge base for designing practice to appear more complex than it really is.

Different instructional theories often use different terms to refer to the same phenomenon which tends to make the knowledge base appear more complex than it really is.

- Beginning a practice session with the more easily obtainable skills
- Providing feedback that supports student ability and effort as the determinants of success in a practice setting
- Redesigning practice items and activities which frequently cause failure

Satisfaction
The concept of satisfaction refers to the idea that learners must feel satisfied that the rewards gained from an activity are consistent with their expectations. Furthermore, an individual must believe that the outcomes of success are directly related to performance on a particular activity. Some strategies to enhance learner satisfaction are:
- Providing an opportunity to practice using a newly acquired skills in a realistic setting as soon as possible
- Allowing those who have mastered a skill to help others practice that skill
- Rewarding intrinsically interesting practice task performance with unexpected non-contingent rewards, and boring practice tasks with extrinsic, anticipated rewards.

Summary and Conclusions
Several prominent instructional design theories are reviewed in this paper and recommendations and prescriptions for designing the practice component of instruction are derived from them. The following general findings and conclusions can be stated based upon this review.

First, the instructional design theories reviewed are generally complementary. However, it is also evident that each theory provides some unique contributions which have important implications for the design of practice. Therefore, in order to design optimally effective practice, the instructional designer will need to be familiar with all of the instructional design theories reviewed, not just one of them.

Second, classifying tasks into types or categories of learning does reveal important differences in the application of the recommendations and prescriptions. In some cases, the differences among categories of learning for a particular recommendation are minor but in other cases the differences are critical to effective learning.

Third, there are several areas of research in cognitive learning theory which are not formally treated in any of the instructional design theories reviewed. These areas of research have important implications for the design of practice. These areas include automaticity, interference, spacing of practice and review, and the use of memory devices and learning strategies. Further development of instructional design theories should more formally incorporate findings from these areas of research.

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Conducting Literature Searches for Instructional Development Projects

Russell T. Osguthorpe
201-C MCKB
Brigham Young University
Provo, Utah 84602

While most instructional developers would agree that some type of literature search should be conducted prior to actually producing a new training program, few would agree on the actual procedures that should be used in completing the search. Because so little attention has been paid to this area of instructional design, there also would likely be disagreement concerning the purposes of conducting the search. Most would agree that a primary purpose would be to avoid the duplication of existing training programs, but is that the only reason for reviewing literature prior to designing instruction? How, for example, is the developer to make the best use of program research and evaluation data that have been collected on the topic of the proposed instructional product?

The purpose of this paper is to describe three types of literature searches that should be conducted as part of the instructional design process: (a) an instructional materials review, (b) a content research review, and (c) an instructional theory review. A suggested set of procedures will be given for completing the searches, following by an account of using the procedure in an actual development project.

Types of Literature Searches

Instructional Materials Search

During most needs assessments a significant amount of information is obtained concerning the instructional materials and approaches being used by the client. However, little information is usually gathered concerning the characteristics of existing instructional products which have goals similar to those of the instructional system being evaluated. In order to obtain such information some type of instructional materials search must be conducted. The purposes of such a search are twofold. First, designers must be certain that the proposed instructional product has not already been developed. Second, just as researchers should attempt to build on existing research, designers should attempt to build on existing instructional approaches by gaining a broad understanding of presently available teaching materials.

The primary difficulty in conducting an instructional materials search is the relative scarcity of appropriate cataloging of such materials in most libraries. While the task of identifying current research in books or periodicals has become streamlined in recent years, the task of identifying instructional products has remained difficult. For example, the library that would provide easy access to hundreds of studies on leadership development may not have on its shelves the most popular leadership training program. Worse yet, the same library may not have any indexing system for determining the existence of such training programs.

An instructional materials search must include procedures not normally used in traditional research literature searches. Consulting indexes to educational media, searching publishers' catalogs, and contacting developers are illustrative of the procedures which must be considered when conducting a materials search. However, since a materials search is not the only search that should be conducted at the beginning of an instructional design project, it can be conducted in conjunction with the other two searches. Following a definition of the two other types of literature searches, an integrated procedure will be given for conducting simultaneously all three types.

Content Research Review

Publishers seldom include quality evaluative data regarding the effectiveness of their instructional products. A designer may conduct a thorough materials search, identifying every existing instructional product in a certain content area, but have little knowledge of current research and theory related to that same content. Using the example of leadership training programs, the designer would benefit from an awareness of the latest research on leadership training—while examining existing programs.

The chief challenge in conducting a content research review is deciding how broad to make it. Carefully reviewing all of the research related to leadership training could consume the greater part of any instructional design project. But when the search is properly limited, insights can be gained in a relatively short period of time, which might not have been gained in any other way. Most content research review will focus first on applied research and second on theoretical studies. Continuing with the example of leadership training, the designer would first be interested in studies which report results of using actual leadership training materials in a seminar setting. These studies might report evaluative data on training programs which have been identified in the materials search. But minimally, information will be obtained which can readily be used in the decision making process of developing a new instructional system.

Since many of the studies conducted in the field of leadership development focus primarily on theoretical questions, the developer may find the applied studies more useful. As with any literature search, the question which initiates the search must be carefully conceived. With a focused question a content research review on leadership development could reveal a variety of creative solutions to problems developers will face as the program is produced.
Instructional Theory Review

The purpose of most instructional theory is to provide prescriptive advice to the designer. The instructional principles that apply to a wide variety of contents and delivery systems can be reviewed rather easily by consulting several major instructional design texts (Briggs, 1977; Dick & Carey, 1978; Gagne, in press; Fleming & Levie, 1979). In addition to these texts, a number of journals might also be consulted, such as: Journal of Instructional Development, or Educational Technology. While it is assumed that most designers have a working knowledge of the information in these texts and journals, it is unlikely that any designers would be equally strong across all categories of learning.

Three types of literature are included in an instructional theory review: (a) general principles of instructional design, (b) theory and research related to a particular category of learning, and (c) principles associated with a specific delivery system. General principles, such as Gagne and Briggs (1979) nine events of learning can be reviewed in existing instructional design texts. In these same texts are more specific prescriptions for separate categories of learning. These basic principles can be used to launch a designer into bodies of research related to a specific category of learning. For example, if a designer were developing a training strategy to teach technicians the names of components in a new color copier, research literature related to discrimination learning (paired-associate drill) would be reviewed. In each category of learning, existing research can often be explored beyond the usual bounds of instructional research. In the category of attitude instruction, for example, little research has been conducted on attitude change from an instructional standpoint, but research has been conducted in psychology concerning attitude formation and persuasion (McGuire, 1969).

In addition to reviewing general principles of instructional design and specific principles from research in the category of learning, designers should obtain information about the particular delivery system proposed for the instruction. A growing body of knowledge is developing, for example, around computer assisted/managed instruction (Chambers & Sprecher, 1983; Lathrop & Goodson, 1983; Merrill et al., in press; Radin & Lee, 1984; Walker & Hess, 1984), tutoring (Allen, 1976; Osuthorpe & Scruggs, in press), cooperative classroom approaches (Aronson et al., 1978; Johnson, 1981), and self-instructional print delivery systems (Johansen, 1982; Talmage, 1975). If a designer selects computers as a central part of the delivery system, a search into the literature related to computer assisted instruction will yield information different from any of the searches suggested previously. Research in the content area, or even in the category of learning being addressed, will not include some of the specific recommendations that relate to CAI systems.

Abstracts, and Sociological Abstracts. It should be kept in mind that each data base includes only those articles published in periodicals and, in some cases, papers presented at conventions which have later been submitted for referencing. Because of the difficulties of indexing articles under appropriate categorical headings, a computer-assisted search should never be considered as a complete listing of all current research in a given area. The advantage of this technique is, of course, the speed with which the user is supplied with the information; the disadvantage is the incomplete, and sometimes, incor-

An instructional materials search must include procedures not normally used in traditional research literature searches.

Strategies for Searching

Whether conducting a literature search for a research project or for a development project, the process is more a creative experience that it is a rigid set of procedures. Because no two bodies of literature are constituted in exactly the same way, the techniques used to extract the most useful information must be tailored to the unique characteristics of the topic being searched. The strategy, therefore, described in this section of the paper should be viewed as a guideline or suggestion—with the understanding that it will be applied somewhat differently each time it is used. The goal of any search is to locate as much relevant information as possible in the shortest length of time. An effective strategy for conducting searches will reduce the amount of time spent, as well as increase the amount of useful information obtained.

Before describing the strategy, a few explanations of general search techniques may be helpful. In recent years computers have played an ever increasing role in library science and search techniques in particular. Most computer assisted search systems allow the user to access several different data bases, such as Current Index to Journals in Education (CCJE), Educational Resources Information Center (ERIC), Psychological
Designers should attempt to build on existing instructional approaches by gaining a broad understanding of presently available teaching materials.

If a developer is interested in programming software for computer-assisted-instruction, a computer-aided search may be useful for identifying existing educational software. A number of database index software packages have been reviewed in periodicals. Among the most useful data bases for instructional designers are: Computer Data Base, Microcomputer Index and MENU—The International Software Data Base.

Step 3—Materials Indexes Search
Two types of sources are available for conducting materials searches: (a) publishers' catalogs and (b) materials reference books. The publishers' catalogs may not be located in a library, but in a school district office or college learning resource center. The reference books are usually easily accessible in the reference section of the social science area of the library.

Begin by locating the desired subject in the card file of the publishers' catalogs collection. Next, go through any of the appropriate publishers' catalogs and record any titles of instructional products that appear to be applicable. Obtain copies of products that are especially close in purpose to the proposed instructional system. (Publishers are often willing to loan copies of materials or products for developers to examine.) It should be noted that certain catalogs are broader in content than others because they include products from more than one publisher (Beckley-Cardy, 1984; Cole, 1984).

If the proposed package includes non-print media in the design, reference books should be searched, such as those published by the National Information Center for Educational Media (NICEM, 1981). This series of books contains a broad listing of educational slides, videotapes, films, audiotapes, and records. Catalogs containing educational computer software are not as accessible as other media catalogs, but are becoming more available each year. For example, Stanton et al. (1984) and Millin and Hays (1985) have published highly useful catalogs of Apple and IBM software in which descriptions of the software as well as evaluative comments are given.

Step 4—The Grapevine Search
Begin a grapevine search by interviewing experts who are easily accessible. Personal interviews are usually more valuable than telephone interviews and should, therefore, be conducted first. In each interview focus on at least three questions: (a) What existing instructional materials are you aware of that relate to my topic? (b) What research studies do you think I should review before beginning my project? (c) Who else do you think I should contact?

Experts in a variety of fields should be considered in the grapevine search. Researchers and developers who have expertise in the content area of interest, as well as the intended delivery system should be included in the search. Since the primary advantages of the grapevine search are speed and currency of findings, personal and telephone interviews should occur throughout the course of any development project.

How Techniques Relate to Types of Searchers
It has been suggested that three types of literature searches should be conducted as part of an instructional development project. It has further been asserted that four main techniques should be used to complete each of the three types. Figure 1 illustrates the relationship between each of the suggested techniques and the three types of searches. Interestingly, the grapevine technique is viewed as one of the most effective overall techniques for obtaining information for all three types of searches. However, for a grapevine search to be
have easy access to a large university library will still be able to locate a relatively complete set of sources needed for a development project.

In the past developers have often expected one technique, such as a computer search or a card catalog search, to yield all of the needed information. As is shown in Figure 1, seldom can one method be relied upon to identify all of the information needed to complete a quality development project. For example, the developer would expect to gain little insight regarding instructional theory from a materials search. A much more efficient approach would be to discuss theory considerations with an instructional scientist and, perhaps, obtain additional references during the conversation for later review. Likewise, although a card catalog or computer search may yield useful information regarding existing materials and theory, these techniques will be most valuable for the content research review.

Each of the techniques described in

Figure 1 can be useful not only at the beginning of an instructional design project, but throughout the development process. Designers often find that unexpected questions arise in the middle or even at the conclusion of the development process. These questions are often best addressed by going to other experts (grapevine) and the literature. Even following the completion of a project, designers can benefit significantly from knowledge obtained through literature searches. Appropriate sources can be used to explain the rationale behind a particular instructional strategy or to aid in the design of appropriate evaluation techniques.
already obtained, along with offering to copy a set of instructional materials which she thought would be most useful in the field, even though they were not designed specifically for tutors.

Finally, a materials index search was conducted by consulting the social sciences reference area in the library. The NICEM index was useful in locating one of the films that was mentioned by the professor during the grapevine search. Publishers' catalogs revealed few commercial moral education materials, but did contain references to some materials on values and decision making that may be useful in the instructional development process.

Because of previous involvement in tutoring projects with special populations, developers already had access to a thorough review on the delivery system (tutoring). Several books and articles were helpful in summarizing evaluative data related to tutoring. Additional research articles (which had previously been identified using each of the major search techniques) revealed one study in which youth offenders participated in a tutoring program. While the content was not moral development, the results of the study were useful regarding implementation techniques with this particular population of students.

The search to this point has provided developers with confidence that instructional design work will be required to produce materials appropriate for the needs of the project. However, the search has also ensured that the resulting materials will be more effective because of others' work in the fields of moral reasoning and tutoring. In this project, as in any design project, the search process will likely continue even after the materials have been developed and evaluated. One of the advantages of a grapevine search is the opportunity it affords of making new acquaintances who sometimes can be of assistance throughout the development process. One of the contacts offered to review any newly developed materials, as well as assist in the dissemination of such materials to other interested educators.

Conclusions
The ideas expressed rest on the following three assumptions: (a) an essential step in the instructional design process is the completion of an effective literature search (b) while similarities exist with searches conducted for research studies, instructional design searches have unique purposes and therefore, require some uniqueness in procedures; (c) if the search process suggested in this paper is followed, the quality of an instructional product may be enhanced. Data to support the third assumption have been based primarily on the author's experience in supervising development teams as they design and produce instructional systems.

Instructional developers generally feel knowledgeable in procedures for writing objectives and conducting task analyses, but often feel inadequate in completing the literature searches required. Because current texts omit discussion of such procedures and because instructional products seldom describe the search techniques used, the topic is not given the attention it deserves. It is hoped that this paper will encourage discussion of effective strategies for conducting searches in the instructional design process and that such discussion will lead to improved instructional systems.

References

The following is a reaction by Earl R. Misanchuk to the article "Comparison of Three Algorithms for Analyzing Questionnaire-Type Needs Assessment Data to Establish Need Priorities" by Oliver W. Cummings that was published in Volume 8, Number 2 of JID.

Earl R. Misanchuk
The University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0

Cummings (JID, 1985, 8(2), pgs. 11-16), using what has sometimes been called the "gap definition" of educational need—the discrepancy between an existing state of affairs and a desired or ideal state—undertook to study three different ways of analyzing educational needs assessment data. Cummings' study is gratifying to the extent that it is an indication that the profession of instructional development is maturing to the point where alternative paradigms can be pitted against one another (as well as against reality), and to the extent that it attempts to deal with some of the more thorny questions in needs assessment, using data generated in a real instructional development situation. The basic idea underlying the article is an excellent one—conducting empirical research on alternative methods, to guide the practitioner in selecting appropriate methods of analysis. There are a number of issues associated with his study, however, upon which I feel obliged to comment. Before launching into the issues, a couple of general comments about the study are in order.

One of the awkward results of a comparative study such as Cummings' is that when it is completed one still does not have a full answer to the question "What method(s) should I use?" Since the conclusions of the study are based upon correlations between rating scales established by different analytical methods, all one is left knowing at the end is which methods agree most with which other methods. Unless there is some external criterion by which to judge which method is the "true" or "correct" one, there seems little point to the exercise. It could possibly be, for example, that the method which agrees least with the others is, in fact, the correct one—the one that best represents reality. Hence the determination of which analytic method to use should be based on some grounds other than comparative ones, unless one of the objects of comparison is known to be better than the others. In this case, superiority of method can only be determined through logical analysis, accounting for how many difficulties one method ameliorates, relative to the other.

The conclusions Cummings is able to reach are, at best, equivocal, and even he admits to their tentative nature, citing limitations of the data set used in the study. The equivocation is, in fact, less a function of the data used in the study than it is a function of the methodology used.

As a second general comment, it should be noted that despite Cummings' claim to the contrary, the statistic VN (del) that he uses as one of the bases of this study is not, in fact, the same as the one proposed as the basis for a two-component proportionate-reduction-in-error (PRE) index of educational need (Misanchuk, 1982; 1984b), or the subsequent multi-component PRE index (Misanchuk, 1984a). Cummings postulates a quite different definition of high educational need (p. 31) than the original VN (Misanchuk, 1984b, p.29). The dimensions RELEVANCE and COMPETENCE (Misanchuk, 1982; 1984b) are most certainly not the same as Cummings' DOES and SHOULD. While the dimension of COMPETENCE approximates the DOES dimension, there is only a remote relationship between RELEVANCE and SHOULD. One could point out a number of differences—SHOULD is prescriptive, while RELEVANCE is descriptive, for example—but that would skirt the main issue: The two questions used to generate the data, "What should be?" and "How relevant is the given skill to your job?" are fundamentally different. The PRE statistic was not invented to do the job Cummings attempts to have it do in his study. This is not to say that it is illegitimate for Cummings to propose the method he does, as an adaptation of VN. In fact, some recent thinking on the nature of educational needs (Misanchuk, 1985) may share more common ground with Cummings' current application than with the original application. Nevertheless, it should be clear to the reader that Cummings' application is, in fact, an adaptation rather than an application of the original construct VN. Because I will have occasion to refer to both the original formulation and Cummings' adaptation in this article, I propose to retain the original notation VN for the original, and use the notation VN for Cummings' adaptation.

Mean Difference Analysis as an Analytic Technique

Cummings correctly identifies some of the problems associated with Mean Difference Analysis (MDA): it requires an (indescribable) assumption that the rating scales yield interval data, and it fails to take into account differences in the absolute importance level of the variable (p. 12). There is at least one other: in order to apply the MDA technique, an implicit assumption must be made that the variance of responses across all stimuli (content areas, in the case of needs assessment) is uniform, and that assumption can rarely be met in the real world. Ignoring the assumption could lead to erroneous conclusions.

To illustrate, suppose two items similar to the ones shown in Cummings'
Figure 1 had the distribution of responses for “Knowledge Level That Does Exist” shown in Table 1 below.

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<td>Hypothetical distribution of responses to two items with same mean and different variances.</td>
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Although both items have the same mean, the variances are vastly different. The information contained in the statistical concept of variance is clearly important to the instructional developer. Given a constant pattern of responses, for both items, to the corresponding “Knowledge Level That Should Exist” dimension, the data illustrated above would indicate that while relatively little need exists for education or training on content Item 1, there is a substantial pool of individuals for whom Item 2 is a high need (and an equally substantial pool of individuals for whom Item 2 has almost no associated need). For the second situation, it would behoove the instructional developer not only to plan for the reduction of the educational need for that subgroup that indicated high need, but also to provide alternative plans for the other subgroup, members of which would undoubtedly be uninterested in the instruction provided the first group. Schwier (1982), one of the first to formalize the application of needs assessment data to the process of instructional design, is a source of additional examples. (The problem of variance has been recognized for some time. Misanchuck and Sciscion (1978) attempted to account for the item variance by converting item means to z-scores, using the pooled inter-item variance, and employing arbitrary cutting points, but were less than successful in accounting for the problem.)

The criticisms of the MDA technique identified above are sufficiently serious that it ought not to be used, no matter how simple it is to calculate or how easy Cummings claims it is to “... describe to an audience that is not well versed in or is even skeptical of statistical analysis” (p. 13). If, in fact, it should not be used, then comparisons involving MDA are spurious.

**Complexity and Communication**

In enumerating the advantages and disadvantages of the various methods used in the study, Cummings states that the $V_C$ statistic is “conceptually and computationally complex and therefore more difficult to “sell” to some audiences” (p. 13). The theory of relativity, the concept of entropy, Maxwell’s equations, and factor analysis are all either conceptually or computationally complex or both. Should we advocate that they not be applied for those reasons? It is true that there is a principle in science that of two equally potent theories, the simpler one is the preferred. However, to apply that principle first requires that the competing theories be equally good at explaining reality.

That $V_C$ is more conceptually and computationally complex than MDA is undeniable. Whether or not it is actually conceptually and computationally more complex than Cummings’ suggested weighted needs index (WNI) is a matter I will return to later. But focussing on those criteria is missing the point. The appropriate question to be asking is “Does $V_C$ do a better job of describing the real world than any competing analytic technique?” Whether the underlying concepts are immediately and intuitively understood by either clients or other laypersons—or indeed even by professionals—is of lesser concern.

Cummings notes that...

...the needs assessment analyst must sometimes communicate with an audience that is neither well versed in nor impressed with statistics. This audience may be skeptical of assumptions about “monotonically increasing marginal probability” or “unit linear progression,” but might embrace the logic which suggests that small discrepancies for important skills may need to be addressed, whereas relatively larger discrepancies for less important skills may not require attention (p. 12).

He appears to be implying that the WNI he describes subsequently does a better job of addressing the latter part of the quoted statement than does the $V_C$ statistic. In fact, everything in the latter part of his statement is true for $V_C$. What Cummings neglects to mention is that the WNI must make some assumptions, too. The very pattern of “assigned values” in his Figure 3 makes inherent assumptions that are not explained anywhere, a point to which I will return later. Cummings seems to be confusing the necessity for making assumptions that underly an analytical technique with the necessity for telling a lay audience what those assumptions are—in gory detail.

In the practice of any profession, there is a language (or jargon) that professionals use to communicate with one another, and a second language they use to communicate with lay people. It is the professional’s responsibility to act as translator, communicating as much or as little as is necessary to satisfy the needs of the clients. If doctors and lawyers feed their clients technical terminology, their clients demand explanations in plain language, or seek the counsel of others. So it can, and should, be with needs assessment.

The del statistic can quite simply be introduced to a lay audience or readership as an index of educational need. The professional should expect to exercise professional judgement in selecting the appropriate statistic to describe the phenomenon. Thus, the professional should select the appropriate statistic, based on his or her understanding of the underlying theory as it coincides with the situation at hand, then present the results and conclusions (not necessarily the underlying theory!) to the client in language the client understands. By way of example, pollsters have attempted to solve this kind of a problem by explaining probabilities associated with their findings in terms such as “correct to within two percentage points nineteen
times out of twenty," rather than referring to standard errors of measurement and alpha levels. Instructional developers should be able to find ways of explaining the del statistic that are easily understandable to almost any kind of an audience—after all, their professional function is to help learners understand complex material.

If there is concern that members of the profession may also have difficulty in following the development of the concepts underlying the statistic, then that is a matter for both preparatory and continuing professional education. The advent of new tools in a profession invariably necessitates the re-focussing and the fine-tuning of professional skills. (The impact of digital electronics on all fields of engineering might be an illustrative, albeit profoundly more powerful, example.) Furthermore, there is probably a point beyond which a practitioner need not venture in the world of theory. For example, one might not completely understand exactly how the statistical probabilities of the values of chi-square found in tables are determined, but may be able to make valid use of the statistic nevertheless. To condone the use of a demonstrably inferior theoretical construct on the basis that it is easy to understand would be professionally inappropriate.

Returning to the point that Cummins’ WNI is conceptually and computationally simpler than $V_C$, one wonders whether the simplicity may be more apparent than real. The derivation of $V_N$ published (Misanchuk, 1982, 1984b) was complicated by the fact that it was necessary to show how that statistic related to, and differed from, the more general statistic from which it was adapted—Hildebrand, Laing, and Rosenthal’s (1977a, 1977b) del. $V_N$ may furthermore appear conceptually complex because the assumptions are explained. As pointed out earlier, WNI makes some assumptions too; Cummins, however, does not identify them, nor explain why they were made. For example, in his Figure 3, the suggested distribution of cell values presumably has some rationale, but the reader is left guessing as to what that rationale might be. Why, for example, is cell (2,4) assigned a value of 2, and not 3, or some other value? On what basis is the change in cell values equal to 1, going from cell (1,5) to (the adjacent) cell (2,5), but equal to 3 in going from cell (1,5) to (the also adjacent) cell (2,4)?

Cummins does make one assumption explicit—that "...the relative ratings of SHOULD and DOES show no need for training development (from an organization point of view) if... the SHOULD rating fails to meet a test of 'moderate to high' in conjunction with 'moderate to low' DOES" (p. 13). He assumes, in effect, that any data outside the upper right hand corner of the matrix in his Figure 3 are relatively unimportant, and can be disregarded.

Cummins' position on this matter is similar to that taken by LeSage (1980), in his development of the dichotomized-additive coefficient. Misanchuk (1980) previously showed why that position is untenable, but another example will illustrate the point. Suppose two items differed in their distribution of responses as shown in Figures 1(a) and 1(b). In 1(a), according to Cummins' suggested procedure, no need is evidenced. Yet obviously, some need exists—not much, perhaps, but some. Certainly, more need is suggested by 1(a) than by 1(b). By essentially throwing away data, the distinction between 1(a) and 1(b) would be lost to the instructional developer. To be sure, the argument is almost academic, however, since both items exhibit relatively low need. On the other hand, consider the information contain-

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Figure 1. Hypothetical distributions, equally regarded as showing no need according to the Weighted Needs Index.
ed in Figure 1(c), as compared with that in 1(b). Using the same argument as presented against MDA through the ex-
ample in Table 1, not capitalizing on the information available, and regarding the distributions of Figure 1(b) and 1(c) equivalent, could have significant negative instructional consequences.

As an aside, it is perfectly possible to postulate and apply the equivalent of the set of weights Cummings recommends, under the PRE approach. Cummings makes the point that the \( V_C \) approach "... does not treat responses above or below any given threshold differently" (p. 13). In fact, the substitution of different error weights could accomplish just that (subject, of course, to the concerns expressed in the last paragraph). The weights postulated by Misanchuk (1982, 1984b) are not sacred, although they do have an explicated logic underlying them. Suggesting a different set of weights simply requires a clearly explicated, persuasive argument as to why the new weights better reflect reality than those originally suggested.

What Cummings appears to be attempting to grapple with is the question of adequacy. Most approaches to needs analysis, including \( V_N \), eschew the question. At best, they are capable of producing a relative ranking of needs, without any consideration for whether or not the learners are already good enough at certain tasks to forgo further training. Different analytic methods approach the problem in different ways—the typical discrepancy approach examines the dimensions SHOULD and \( V_C \), while the PRE approach examines the dimensions RELEVANCE and COMPETENCE—but the questions of a criterion of adequacy is largely ignored. Recently, however, Misanchuk (1985) posed for discussion an approach that involves examining the dimensions RELEVANCE and COMPETENCE in those cases where the learner is below the criterion of adequacy, and the dimensions COMPETENCE and DESIRE in those cases where the learner is at or beyond that criterion. In summary, it is heartening to see Cummings attempt to address the too-long-ignored question of adequacy, but the solution he posits—ignoring everything but the upper-right-hand corner of the data matrix—falls short of the mark.

Let's return now to the point of computational complexity. Without having collected empirical evidence on the matter, I would venture to guess that for most people, the difference in computational complexity between the WNI and \( V_C \) would not be an issue. Both formulas require the summing of products across two dimensions. The elimination of the subtraction contained in the \( V_C \) statistic is trivial. With computers becoming increasingly commonplace in the professional's toolbox—including Cummings' own (p. 14)—it is difficult to see why the issue of computational complexity is raised at all.

**Similarity and Difference**

Examination of the two formulas leads to the last point I wish to make: the WNI is really very similar to \( V_C \). As Cummings notes, the acceptance of the assumptions associated with \( V_C \)—the set of error weights and marginal values proposed by Misanchuk (1982, 1984b)—causes the denominator of \( V_C \) to reduce to a constant. Linear transformations such as division by a constant or subtraction from a constant do not affect the relative value of a statistic in any salient way, although they do change the actual value. Cummings posits a set of "cell values"—which are functionally equivalent to error weights—and he proposes using cell frequencies rather than proportions—but also divides them by \( N \), the total number of respondents, which of course ultimately yields cell proportions. The changes that Cummings suggests in moving from \( V_C \) to the WNI—especially the elimination from consideration of two-thirds of the cells in which data could potentially accrue—are non-productive at best and counter-productive at worst. Finally, since \( V_C \) and by analogy \( V_N \)—are adaptations of a statistic which is quite well developed and understood (Hildebrand, Laing, & Rosenthal, 1977a, b), there are already available ancillary statistics (standard error, tests of significance, etc.) that could prove useful in the analysis of educational and training needs. Analogs for the WNI presumably do not yet exist.

**Conclusion**

In mis-applying \( V_N \) to the SHOULD-DOES situation, Cummings may very well have inadvertently discovered a legitimate application of PRE analysis. In using that mis-application, \( V_C \) as a "straw man" for comparison with the WNI, however, he focused on the wrong features of the statistic. If it could be shown, through germane, rational argument—including the explication of assumptions—that either the WNI or \( V_C \) is appropriate for the analysis of discrepancy needs analysis data, then a real contribution would have been made. (The appropriateness of the discrepancy conceptualization of educational and training needs, as opposed to the needs components conceptualization, is a separate matter entirely.) Focusing on characteristics of the statistic that are of secondary importance and ignoring implicit underlying assumptions in the name of convenience and simplicity of communication, however, do little to further the advance of needs analysis. Until persuasive, germane arguments are forthcoming, there seems little reason to discard \( V_N \) in favor of either the WNI or \( V_C \).

**References**


Use of Learner Data in Selecting Instructional Content for Continuing Education

Joan E. Watson
University of Pittsburgh
School of Nursing
426 Victoria Street
3500 Victoria Street
Pittsburgh, PA 15261

and

John C. Belland
The Ohio State University
College of Education
29 West Woodruff
Columbus, OH 43210-1177

Abstract. In order to use the rich data available about the knowledge and professional practice of Physician Assistants (PAs), it was necessary to develop a methodology to organize and relate information about patients seen in practice, perceived needs, and prior knowledge both in terms of the PA role and the content to be taught. Such a process may be useful to consider in the design of instructional materials for other populations and other settings.

Most instructional development models stipulate analyzing the learners as one step in the development process. Instructional developers in actual practice often use few learner data. The Physician Assistant Self Assessment Project was unique in this regard. An extensive self assessment instrument was administered nationally to Physician Assistants (PAs). This assessment provided the following types of data about Physician Assistants: body system knowledge, number and type of patients seen in the PA practice, PA perceived need for continuing education, and professional role performance (D’Costa, 1982). All of these data were considered in suggesting topics for continuing education materials. The means by which these data were used in the Instructional Systems Design (ISD) process of developing continuing education materials can be adopted easily by other instructional designers working in a variety of settings.

Physician Assistants constitute a new profession, one evolving from medical care shortages, particularly in rural areas. Some of the first PAs were trained by their employing physician and received little or no formal education. Today, PAs can enter the profession through a two-year post-secondary training program. However, many PAs have had military medic experience, obtained baccalaureate and graduate degrees, or achieved a variety of other relevant education and experience to add to formal training. PAs are state certified under a variety of regulations, but all are required to be supervised by a licensed physician. They must pass a PA certifying examination every six years in order to practice.

The goal of this instructional systems development project was to design and produce 18 self-paced learning modules that would assist the individual PA in remediating the deficiencies identified by the self-assessment examination. No single set of data resulting from the PA Self Assessment test was considered adequate for developing continuing education modules. For example, while PAs as a group may have received low scores in a body systems category, the designer must ask the question, “Is it necessary to develop training in a particular disease if PAs do not encounter that disease in their practice?” Thus, five data sets were studied to determine the content areas for module development. Those were: (a) practice profile, (b) need profile, (c) role perception, (d) body systems knowledge, and (e) question distribution in the examination. The data which measures each criterion will be discussed below. Then, the way these data were applied to the content specifications for the Instructional Systems Design (ISD) process will be described.

Self-Assessment Examination

The Self-Assessment Examination for Physician Assistants is an extensive and intensive set of measures which takes an average of six hours to complete. It is scored objectively and normally is used to provide feedback to PAs on their professional strengths and weaknesses.

The examination questions were developed by an item writing committee of health professionals utilizing a critical incident technique (D’Costa & Watson, 1983). Critical incidents in a PA practice were identified by a team of practicing PAs, PA educators and physicians. The distribution of the resultant examination items was approved by this team of health professionals in order to produce an examination that was a valid representation of typical PA practice. The self-assessment examination was sent to 2,200 physician assistants. Three months later, 891 PAs had returned their completed exams. The availability of these data provided a unique opportunity to identify normative performance patterns for the PA profession and to use these data in designing a continuing education system.

PA performance on the Self-Assessment Examination defined competency at two levels—entry and advanced. Data to describe these competency standards were provided by an advisory committee using a modified Nedelsky Technique¹ (Nedelsky, 1954). The entry level was interpreted as the expected level of competence for a generalist PA. The entry level standard and reliability for the 17 role scales are reported in Table 1. (D’Costa, 1982). Those PAs who achieved the entry level standard were identified as having “passed” that scale. Ideally, all PAs could be expected to demonstrate entry level standards on all scales. However, most PAs focus their practice in a specific specialty which, over time, weakens their competency in other areas. The PAs in this sample were competent in approximately three-fourths of the scales.

¹Nedelsky Technique was modified to include competency on an advanced as well as entry level.
Table 1
ENTRY LEVEL STANDARD AND RELIABILITY INDEX FOR ROLE SCALES

<table>
<thead>
<tr>
<th>SCALE #</th>
<th>ITEMS</th>
<th>MAX SCORE</th>
<th>ENTRY LEVEL STANDARD</th>
<th>( \cdot k^{20} )</th>
<th>CA</th>
<th>SEM</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>20</td>
<td>17.00</td>
<td>15</td>
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<td>1.08</td>
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<td>56</td>
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<td>22</td>
<td>92</td>
<td>1.65</td>
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<td>3</td>
<td>18</td>
<td>72</td>
<td>58.83</td>
<td>42</td>
<td>73</td>
<td>2.03</td>
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<td>4</td>
<td>15</td>
<td>60</td>
<td>45.17</td>
<td>21</td>
<td>95</td>
<td>1.79</td>
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<td>29</td>
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<td>18</td>
<td>72</td>
<td>59.92</td>
<td>30</td>
<td>61</td>
<td>1.99</td>
</tr>
<tr>
<td>7</td>
<td>30</td>
<td>120</td>
<td>94.83</td>
<td>50</td>
<td>67</td>
<td>2.75</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>52</td>
<td>40.33</td>
<td>31</td>
<td>75</td>
<td>1.91</td>
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<td>72</td>
<td>55.17</td>
<td>33</td>
<td>80</td>
<td>2.21</td>
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<td>30</td>
<td>120</td>
<td>94.75</td>
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<td>64</td>
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<td>17</td>
<td>20</td>
<td>80</td>
<td>62.33</td>
<td>26</td>
<td>57</td>
<td>2.18</td>
</tr>
</tbody>
</table>

Codes Used: \( k^{20} \) = Kuder-Richardson reliability index
CA = Coefficient of Acceptance (a more appropriate reliability index for competency tests)
SEM = Standard error of measurement

Figure 1
Sample Test Items

Item 175 - In a typical month, approximately how many patients do you see for the following types of acute care (defined as having onset of minutes to hours)?

Respiratory (e.g., pulmonary embolism, pneumonia)
A. 0 to 3
B. 4 to 6
C. 7 to 10
D. 11 to 15
E. More than 15

Body Systems + Context of Care

Item 161 - How comfortable do you feel about your performance with patients requiring the following types of emergency care (defined as being life threatening)?

Cardiovascular (e.g., myocardial infarction, arrhythmia)
A. Very uncomfortable
B. Slightly uncomfortable
C. Comfortable
D. Quite comfortable
E. Very comfortable
In order to focus attention on the content of the continuing education system, it was necessary to focus on the scales (role and body systems) in which the PA sample scored the poorest. The scales in which fewer than 70 percent of the PA sample showed competence were identified as indicating a need for remediation; and those scales in which fewer than 50 percent of the PAs showed competence were considered to indicate a more severe need for remediation.

**Practice Profile**

The practice profile was based on the number of patients seen by the physician assistant. The self-assessment examination included 30 questions designed to obtain these data. For example, item 175 refers to acute care practice (Figure 1). The questions were categorized by body system (cardiovascular, respiratory, musculoskeletal) as well as context of care (emergency, acute, chronic). A few health care problems were listed as examples of each category.

The practice profile for this sample is presented in rank order in Table 2. Some of the more common practice areas are: chronic cardiovascular, acute musculoskeletal, chronic respiratory, chronic endocrinology.

**Need Profile**

The perceived educational need profile of this sample was generated by physician assistants’ responses to 30 questions. The questions were intended to ascertain how comfortable the physician assistants felt about their performance with patients in the categories of body systems and context of care (Figure 1, Item 161). The perceived need of the physician assistants in this sample is presented in rank order in Table 3.

**Role Perception Scale**

Fisher and Faulman (1979) in their role delineation study of the PA profession identified 11 major responsibilities of the physician assistant. These responsibilities are:

1. Recognize interdependent relationship with supervising physician.
2. Demonstrate professional behavior.
3. Promote preventive health care.
4. Establish health status data base.
5. Analyze data base.
6. Formulate health management plan.
7. Implement health management plan.
9. Establish effective interpersonal relationship with patients, professionals, and others.
10. Promote acceptance of the role.

In order to develop specific knowledge test items from which meaningful feedback could be derived, the 11 broad areas of performance were combined with body systems to form 17 role scales. Role delineation is described as a process by which an occupational group declares to the public its responsibilities for services (D’Costa, 1982, March). The scores of the 891 physician assistants on the self-assessment examination were reported in the scales that resulted from a previous role delineation study. These role scale needs were identified using two arbitrary criteria: fewer than 70 percent of PAs passed of fewer than 50 percent passed.

**Body Systems Knowledge Scales**

The 28 body systems knowledge scales were derived from 12 body systems and three types of medical intervention identified in a previous PA role delineation study (Fisher & Faulman, 1979). These resulting 28 body systems scales are listed in Table 4. At least six examination items were assigned to each of the 28 body systems scales. The body system scale needs for continuing education also were categorized by degree: fewer than 70 percent of the sample passed and fewer than 50 percent of the sample passed.

**Question Distribution in the Examination**

The last criterion used to determine module development was the extensiveness of questions on a particular subject within the examination. The number of questions on each body systems scale was based on the role delineation of the profession, which was based on what physician assistants actually do in their daily practice. The 320 examination items were divided between the scales according to PA practice. The intent was to have the Self-Assessment Examination resemble the physician assistant practice as closely as possible. Therefore, if a small percentage of PAs passed a scale heavily weighted with questions, a
critical need for continuing education emerged. However, when a small percentage of PAs passed a scale represented by only a few questions, a less significant need for remediation resulted.

Content Specification in the ISD Process

The ISD model (Belland, 1981) used in this project calls for the instructional content to emerge from the integration of program objectives with learner characteristics. Rarely do instructional designers have the quality or quantity of data required to make content decisions based on such an integration. The areas of greatest need for PA Continuing Education were determined by combining the available data into a two-dimensional matrix (Table 4). Each body system scale was considered individually in light of the five criteria previously discussed. The following tally system was used to rate the priority of these data:

1. One point was assigned to each scale for each mark in the four categories of practice profile, need profile, role perception, and body systems knowledge.

2. Those scales (body systems knowledge and role) that most PAs passed were assigned a zero rating, even if PA practice and need were indicated. Since the continuing education materials were to be assigned based on deficiency, the scales that most PAs scored well on could be eliminated from the priority rating easily.

3. One point was subtracted from each scale where practice was not indicated as common.

4. Since the number of test items per scale was based on actual PA practice, one point was added to each scale consisting of more than 12 items.

5. One point was added to scales where need was indicated in all of the four categories.

The scales were then assigned a first, second or third priority based upon the total points assigned. The priorities were then adjusted according to the diversity of critical incidents represented in the scale, national data indicating common PA practice, and the quality of instructional materials currently known to be available to PAs. For example, body system acute respiratory received an initial rating of 4. One point was added because the scale was comprised of more than 12 test items, for a total of 5 points and a first priority rating. The body system acute genitourinary also received an initial rating of 4 but was reduced to 3 due to fewer items on the examination. Acute genitourinary was assigned a second priority rating.

The project contract provided for development of 18 instructional modules. In an attempt to provide the most thorough continuing education in the areas of greatest deficiency, these 18 modules were apportioned across only that content which was rated first or second priority. The greatest number of modules was assigned to content rated first level priority. Each content area rated second priority was assigned only one module. Each first priority area was assigned a number of modules based on the diversity of content represented by the scales, and the instructional materials currently available in that content area. These priorities and apportionment of instructional modules were

| Table 4 |
| Module Data Analysis |

<table>
<thead>
<tr>
<th>Body System</th>
<th>Scale</th>
<th>Practice Profile</th>
<th>Need Profile</th>
<th>Role Scale Needs</th>
<th>System Scale Needs</th>
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</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>X</td>
<td>Common</td>
<td>Uncomfortable</td>
<td>X</td>
<td>&lt;70% Competent</td>
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<tr>
<td>Respiratory</td>
<td>X</td>
<td>XX</td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Neurology</td>
<td>X</td>
<td>XX</td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ACUTE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>X</td>
<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>X</td>
<td></td>
<td>X</td>
<td>3</td>
<td></td>
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<tr>
<td>Respiratory</td>
<td>X</td>
<td></td>
<td>XX</td>
<td>3</td>
<td></td>
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<tr>
<td>Gastrointestinal</td>
<td>X</td>
<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Genitourinary</td>
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<td></td>
<td>XX</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Neology</td>
<td>X</td>
<td></td>
<td>XX</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Endocrine</td>
<td>X</td>
<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
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<tr>
<td>Cardiovascular</td>
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<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal</td>
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<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>X</td>
<td></td>
<td>XX</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>X</td>
<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Genitourinary</td>
<td>X</td>
<td></td>
<td>XX</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Neology</td>
<td>X</td>
<td></td>
<td>XX</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Endocrine</td>
<td>X</td>
<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Eye &amp; ENT</td>
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<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Hematology</td>
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<td></td>
<td>X</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Reproductive</td>
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<td>XX</td>
<td>3</td>
<td></td>
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<tr>
<td>Psychosocial</td>
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<td></td>
<td>XX</td>
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JOURNAL OF INSTRUCTIONAL DEVELOPMENT
presented for approval to an advisory committee consisting of PAs, PA educators and physicians.

Conclusion
Too often, instructional developers are expected to produce materials without access to data which adequately describe learner characteristics. In other situations, the instructional developer does not know how to use those learner data that are available. While most ISD models include consideration of learner characteristics in designing instructional materials, the method by which this can be accomplished is obscure. In the ISD project presented, learner data were available and were used to identify the content for 18 continuing education instructional modules for PAs. This method can be applied to a wide variety of health related and non-health related instructional design projects where similar learner data can be obtained. Utilization of learner data in this manner provides the instructional designer with precise criteria required to select content for instruction.

References
Awards Program for Outstanding Achievement in Instructional Development

This year, the Division for Instructional Development (DID) is again planning to offer awards to recognize outstanding achievements in the instructional development field. THIS YEAR THE NOMINATION PROCESS HAS BEEN SIMPLIFIED SO AS TO ENCOURAGE A GREATER NUMBER OF PEOPLE TO APPLY. YOU ARE STRONGLY ENCOURAGED TO NOMINATE YOUR OWN WORK. ALL NOMINATIONS MUST BE POSTMARKED BY OCTOBER 31, 1986. Information about each of the awards is presented below.

This year's awards categories are:

- Outstanding Practice in Instructional Development
- Outstanding Book in Instructional Development
- Outstanding Journal Article in Instructional Development
- Robert M. Gagne Award for Graduate Student Research in Instructional Development
- Outstanding Practice by a Graduate Student in Instructional Development
- Presidential Award for Outstanding Service to the Division for Instructional Development

Outstanding Practice Award

This award will be given to those individuals or groups that have developed exemplary instructional materials or systems. The materials or systems must have been developed after 1983. To be considered for the award, send the material or system that was developed (or a description of the material or system), along with a cover letter to:

Dr. Marcy Driscoll  
305 Stone Building  
Florida State University  
Tallahassee, FL 32306  
Telephone: (904) 644-4583

In assessing the quality of the work submitted, judges will examine:
- the instructional events (activities) that constitute the materials or system
- the directions for using the materials or system
- performance data and/or attitude data regarding the effectiveness of the instructional materials or system

You may want to briefly discuss these items in your cover letter.

Outstanding Book Award

Books nominated must have been published after 1983, and should be relevant to the field of instructional development. Anyone (readers, authors, or publishers) who is aware of a book that they believe warrants an award is encouraged to nominate it. The nomination procedure is outlined below:

a. Nominations will be by signed letter. No anonymous nominations will be accepted. You may include a short statement providing your rationale for nominating the book.

b. Complete bibliographic information should be included: author, name of book, where published and by whom, date of publication, and ISBN number if known.

c. Authors and publishers should indicate whether review copies will be furnished upon request of the judges.

d. You may provide as enclosures: copies of reviews, promotional literature, or other informational materials which help to describe the nature and quality of the book.

e. Send one copy of the nominating letter and five copies of all enclosures to:

DID Outstanding Book Award  
c/o Dr. R. A. Braden  
Department of Educational Media & Technology

Outstanding Journal Article Award

Articles nominated must have been published after 1983 in a regularly published journal, and should be relevant to the broad field of instructional development. Anyone may submit a nomination. The nomination procedure is outlined below:

a. Nominations will be by signed letter. No anonymous nominations will be accepted. Self-nominations are welcomed. If you desire, you may include a short statement providing your rationale for the nomination.

b. A complete bibliographic citation should be included in the letter.

c. Send one copy of the nominating letter, and three (3) copies of the article to:

DID Outstanding Journal Article Award  
c/o Marc J. Rosenberg  
AT&T Communications  
9K147  
140 Centennial Avenue  
Piscataway, New Jersey 08854  
Telephone: (201) 457-7193

Robert M. Gagne Award for Graduate Student Research in Instructional Development

This award will be given to a graduate student who has made a significant contribution to the body of knowledge upon which instructional development is based. The work must have been completed after December 31, 1983, while the nominee was enrolled as a graduate student. The award includes a $500 stipend.

You may nominate any individual (including yourself) for the Robert M. Gagne Award. In order to nominate someone, send a copy of the single piece of work (journal article, dissertation, etc.)

East Texas State University  
Commerce, Texas 75428  
Telephone: (214) 866-5496
for which they are being nominated, along with a short cover letter, to:

Dr. Gary J. Anglin
Taylor Education, Room 136B
University of Kentucky
Lexington, Kentucky 40506-0001
Telephone: (606) 257-5972

Outstanding Practice by a Graduate Student in Instructional Development

This is a $500 award sponsored by the AT&T Communications Sales and Marketing Education Division. The award will be given to a graduate student in the field of instructional development who has applied instructional development procedures in an exemplary manner. Application of the procedures may have resulted in a new or revised instructional product or system, or some other output.

You may nominate anyone (including yourself) for this award. However, the work for which the person is being nominated must have been done while he or she was a graduate student and must have been completed after December 31, 1983.

Nominations should be in the form of a 3-5 page (8-1/2" × 11" paper), typewritten, double-spaced summary of the work done by the individual. Summaries should include a brief description of:

- The instructional problem that was addressed
- The instructional development procedures that were employed in order to solve the problem
- The magnitude of the development effort in terms of time and cost
- The instructional events (activities) that constitute the instructional product or system
- How the product or system was designed so as to insure proper implementation
- The means by which the product or system was disseminated
- Evidence of reduction or elimination of the problem, including performance data, attitude data and/or cost-effectiveness data

In addition to the information listed above, be sure to include, on a cover page:

- The name, address, and telephone number of the nominee
- Your name, address, and phone number

Mail one copy to:

Dr. Burton Hancock
AT&T Communications Sales & Marketing Education Division
15 West Sixth Street, 5th Floor
Cincinnati, Ohio 45202
Telephone: (513) 352-7788

Outstanding Service Award

This award will be given to an individual who, over the past five years, has performed continuously outstanding work for the Division of Instructional Development (DID). The DID President will choose the winner of the Service Award from among all the members of DID. Unlike the other award categories, nominations for the Service Award are not necessary. However, the DID President welcomes your suggestions regarding potential recipients of this honor. Send your suggestions to:

Dr. Maurice Coleman
Educational Planning
Arthur Anderson & Company
1405 N. 5th Avenue
St. Charles, Illinois 60174
Telephone: (312) 377-3100