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 programed instruction and nonprogramed material is that programed instruction increases the probability of a correct answer, while nonprogramed 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 CAI, 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

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

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 auditorially 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 those that don't. This "verbalization" of the stimulus and semantic encoding may be facilitated by the use of questions in the instructional material.

Questions may also serve an "elaborative" function. Elaboration is the storage of additional information that puts the new stimulus into a meaningful context (Kumar, 1971). Although most of the research on this concept involved paired associate learning, it is likely to have implications for learning propositions as well. If questions help make information to be learned more meaningful, it is more likely to be learned. This is a good argument for asking questions that build on what a learner already knows.

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 response form is probably unimportant" (p. 104).

Providing for Rehearsal

The third function that questions might serve is to provide for rehearsal. Rehearsal is defined by Kumar (1971) as the "search for an effective mnemonic." The research on adjunct questions found that when questions were presented *after* a segment of instructional material, they aided the retention of the material to which they were directed, but they did *not* depress performance on incidental material. One might conclude that prequestions serve as attentional devices, while post-questions function in a rehearsal role. Kumar (1971) presents

Questions serve to establish and maintain attention, to facilitate encoding, and to provide for rehearsal.

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 "recency 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 prequestions 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 precursory 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.

A possible solution to this limitation of the computer is to accept a constructed response without judging it, and then present a model answer to the learner for their evaluation. However, there seems to be a tendency for designers of CAI to have the computer judge every response of the learner. This seems to be a weakness in current thinking about how to best use the medium at 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 that it should be accompanied by a question testing whether or not the learner understands what it represents (Markle, 1966).

• Avoid abbreviations. Spell out words completely and use complete sentences when possible (MECC, 1981).

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 expectations 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).

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 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, anticiapted wrong answers, and inanticipated answers.

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 "takenapart" (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

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 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 is 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 increases 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 when 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.

• 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.

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

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.

Kumar, V. K. (1971). The structure of human memory and some educational implications. *Review of Educational Research, 41*(5), 379-417.

Ladas, H. (1973). The mathemagenic effects of factual review questions on the learning of incidental information: A critical review. *Review of Educational Research, 43*(1), 71-82.

Markle, S. M. (1966). *Good frames and bad: A grammar of frame writing.* NY: John Wiley.

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

References

Alessi, S. M. & Trollip, S. R. (1985). *Computer based instruction: Methods and development.* NJ: Prentice Hall.

Anderson, R. C. (1970). Control of student mediating responses during verbal learning and instruction. *Review of Educational Research, 40*(3), 349-369.

Anderson, R. C., Faust, G. W., & Roderick, M. C. (1968). "Overprompting" in programmed instruction. *Journal of Educational Psychology, 59*, 88-93.

Bull, S. G. (1973). The role of questions in maintaining attention to textual material. *Review of Educational Research, 43*(61), 83-87

Control Data Corporation. (1977). CDC Author Guide. Minneapolis, MN: Author.

Crowder, N. A. (1960). Automatic tutoring by intrinsic programing. In A. Lumsdaine & R. Glaser (Eds.) *Teaching machines and programed learning: A source book.* Washington, D.C.: National Education Association.

Espich, J. E., & Williams, B. (1967). *Developing programmed instructional materials: A handbook for program writers.* CA: Fearon Press.

Frase, L. T. (1970). Boundry conditions for mathemagenic behaviors. *Review of Educational Research, 40*(3).

Frase, L. T. (1971). Effect of incentive variables and type of adjunct question upon text learning. *Journal of Educational Psychology, 62*, 371-375.

Friend, J., & Milojkovic, J. D. (1984). Designing interaction between students and computers. In Walker, D. F. & Hess, R. D. (Eds.), *Instructional software: Principles and perspectives for design and use,* (pp. 143-150). CA: Wadsworth Publishing Co.

Gagne, R. M. (1985). *The conditions of learning,* (4th ed.). New York: Holt, Rinehart and Winston.

Gall, M. D. (1970). The use of questions in teaching. *Review of Educational Research, 40*(5), 707-721.

Holland, J. G. (1965). Research on programming variables. In R. Glaser (Ed.), *Teaching machines and programed learning II: Data and directions.* Washington, D.C.: National Education Association.

Kulhavy, R. W. (1977). Feedback in written instruction. *Review of Educational Research,* 47(1), 211-232.

Minnesota Educational Computing Consortium, (1981). *Designing instructional computing materials.* Minneapolis, MN.: Author.

Peters, H. J. & Johnson, J. W. (1978). *Author's guide,* CONDUIT. Iowa: University of Iowa.

Rothkopf, E. Z. & Bisbicos, E. E. (1967). Selective facilitative effects of interspersed questions on learning from written materials. *Journal of Educational Psychology, 58*, 56-61.

Seiler, B. (Ed.) (1981). *Guidelines for designing PLATO lessons.* Delaware: University of Delaware, Office of Computer Based Instruction.

Skinner, B. F. (1958, October). Teaching Machines. *Science, 128.*

Suppes, P. & Ginsberg, R. (1962). Application of a stimulus sampling model to children's concept formation with and without overt correction response. *Journal of Educational Psychology, 63*(3), 30-36.

Wager, S. U. (1982). *The effect of immediacy and type of informative feedback on retention in a computer-assisted task.* Unpublished doctoral dissertation, Florida State University, Tallahassee.