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A Meta-Analysis on the Effects of Computer-Presented Feedback on Learning from Computer-Based Instruction

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ABSTRACT

A Meta-Analysis on the Effects of Computer-Presented Feedback on Learning from Computer-Based Instruction

Roger Azevedo

Quantitative and qualitative meta-analytic approaches were used to synthesize the empirical evidence of the effects of feedback on learning from computer-based instruction Despite the widespread acceptance of feedback in computerized instruction, empirical support for particular types of feedback information has been inconsistent and contradictory Effect size calculations from twenty-two (22) studies involving the administration of immediate achievement posttests resulted in a weighted mean effect size of 0 80 Also, a mean weighted effect size of 0 35 was obtained from nine (9) studies involving delayed posttest administration Feedback effects on learning and retention were found to vary with computer-based education typology, format of unit content and access to supplemental materials Results indicate that the diagnostic and prescriptive instructional management strategies of computer-based adaptive instructional systems provide the most effective advisement by providing the optimal amount of practice needed to facilitate the acquisition of defined objectives. The implementation of effective feedback in computerized instruction involves the computer's ability to verify the correctness of the learner's answer and the underlying causes of the error

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DEDICATIONS

I dedicate

this thesis

to my parents.

HENRIQUETA and OSCAR

and my sister.

MARIA ISABEL

Who's LOVE, HONESTY, and BRAVERY throughout many insurmountable life events have taught me the basic tenets of LIFE:

BELIEVE IN MYSELF

PURSUE HAPPINESS

and

STRIVE for EXCELLENCE

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Feedback

Feedback is the information given to learners about the correctness of their answers (Frayer & Klausmeier, 1971) Feedback has been regarded as a critical component of instruction (Schimmel, 1988), a necessary part of programmed instruction (Suppes & Morningstar, 1969), a basic requirement in learning (Glaser & Cooley, 1973, Lysakowski & Walberg, 1982), and fundamental to the rationale for computer-assisted instruction (Bardwell, 1981; Cronbach, 1977), computer-based adaptive instruction (Tennyson & Rothen, 1979) and intelligent tutoring systems (ITS) (Rickel, 1989)

> Picture a student working hard in a computerized algebra course. At one point, the student answers several examples incorrectly How should the program respond to help the student learn? Do the errors indicate a lack of understanding, or are merely "careless"? Should the errors be pointed out? If so, how much, or what kind of explanation should be provided about the incorrect answers? (Jonassen, 1988, p. 183)

Feedback refers to a message or a series of messages that is evaluative and intended to improve the functioning of a system (Kowitz & Smith, 1985). The intention is to correct any variations from the prescribed activities and to reinforce and thereby encourage the continuation of activities which are perceived as moving in desirable, productive directions (Kowitz & Smith, 1985)

Feedback must not be confused with reinforcement. Reinforcement involves generating new behaviors by assembling existing skills into new patterns or by building entirely new skills Feedback, in contrast, consists of restoring equilibrium to an established system. According to the cybernetic model, effective feedback is always negative (Schoderbek, Schoderbek & Kefalas, 1990)

Feedback is any message or display that the computer presents to the learner after a response (Wager & Wager, 1985) The communication between both entities could range from a simple "yes" or "no" (knowledge of results), or "answer C is correct" (knowledge of correct results), to an elaborate explanation as to why the answer is incorrect, possibly with hints

regarding how to find the correct answer (elaborate feedback) Feedback may also be a statement of praise, and animated graphic, or an auditory cue used to signal to the learner the correct/incorrectness of his/her response (Wager & Wager, 1985)

Numerous operational definitions of feedback have been proposed by researchers in the field. Merrill (1987) has defined feedback as corrective, reinforcing information provided to the student based on his correct or incorrect response to a question Feedback promotes learning through instruction by providing students with information about their performance (Mory, 1992) According to Steinberg (1991) feedback is a message that is presented to a learner after she gives a response The mode of the message may be visual or aural, verbal or nonverbal The content of the feedback may vary from simple to complex Feedback is used to signal whether the student has correctly retrieved specific information or has correctly applied recently studied concepts or procedures to familiar or novel tasks (Bangert-Drowns, Kulik, Kulik & Morgan, 1991)

Feedback is the knowledge of results a learner receives about performance (Tessmer, Jonassen & Caverly, 1989). The computer feeds back a message to the learner regarding what they did and why it was right or wrong According to Tessmer *et al.* (1989) properly designed feedback messages allow learners to correct any errors in their performance and affirm to themselves what they are doing right Until students know they are right, or how they are wrong, the learning they derive from practice is incomplete Thus, the inclusion of feedback in computer-based education (CBE) is paramount to the learning process

Computers as Delivery Systems for Instructional Materials

Computer are capable of delivering adaptive, individualized instruction complete with textual, auditory and visual stimuli (Sales, 1988) The use of new technologies introduces additional complexity in the design and delivery of feedback.

The versatility of the authoring tools is a crucial factor in the development of useful CAI lessons (Richards & Fukuzawa, 1989) The choice of authoring tools fall in two categories, authoring languages or systems. Authoring systems are software programs that allow the user (author) with no programming skills the ability to develop computer-assisted learning (CAL)

lessons The CAL lessons usually consist of multiple choice true/false type questions, branching and tabulation of student responses An authoring language, in contrast, is like a computer language consisting of a set of commands that allows the developer more versatility in terms of offering the user more options regarding redemption, interpretation of user responses, etc

The problems associated with the use of authoring systems are the limitations involving the incorporation of branching and sequencing strategies, answer processing, and the provision of simple noncorrective feedback messages. Software limitations force the author to use multiple choice and T/F questions This forces the author to anticipate the errors users are likely to make and therefore provide "canned" feedback messages "Canned" feedback messages are of limited instructional use since they most often consist of simple messages regarding the response's correctness. These simple statements have limited instructional value since they fail to provide the necessary information for the student to understand the nature of his/her misconception. According to Richards & Fukuwaza (1989) one should select authoring systems that are capable of handling feedback issues through branching and/or remedial sequence capabilities and HELP options

Intelligent tutoring systems (ITS) programs such as the ones developed by Anderson and Reiser (1985) have potential benefits, such as modeling the learner's current learning state, diagnosing learner misconceptions and providing appropriate pedagogical interventions, but they require extensive development time and a substantial amount of computer capacity (Schimmel, 1988)

CBE Typologies

Programmed Instruction (PI)

Programmed instruction provides the learner with a series of short "frames" of information (Skinner, 1968) Each frame contains a question concerning the information of that frame The learner writes a response and then checks the accuracy of his/her answer. Feedback confirms the correct response and is thought to reinforce the response, thereby increasing the probability that it would be elicited under similar stimulus conditions (Wager &

Wager, 1985) The progression through instruction is in a linear fashion, hence the name "linear programs" According to Skinner (1968), the student's response is equated with learning Instruction is based on the behavioral principle of successive approximation to a goal

Another approach to programmed instruction, intrinsic programming, involves the presentation of information in larger chunks followed by multiple choice questions (Crowder, 1960). Correct responses lead the student to advancement with the instructional unit, otherwise the program would "branch" to a remedial frame The remediation process involves redisplaying the incorrect answer, presenting an explanation as to why it was wrong, then branching back to the original question frame The purpose of feedback is to allow the student to check his/her understanding of the material, so he/she can correct misunderstandings before proceeding to new material

Computer-Assisted Instruction (CAI)

Computer-assisted instruction is a generic term that includes several types such as drill and practice, tutorial and dialogue systems In drill and practice, the computer serves primarily to reinforce concepts that were introduced in the classroom For example, the learning of addition facts With the tutorial, the computer not only reinforces concepts but also introduces them An example of this would be having the computer introduce the concept of topic sentences and then providing a series of paragraphs from which the student is expected to select the topic sentence The dialogue is the most sophisticated of these forms. It presents lessons and practice exercises. These three approaches can be collectively termed as computer-assisted instruction (Niemiec & Walberg, 1987)

Due to its interactive capabilities, the computer can be programmed to adapt instruction to the needs of the individual learner Examples of simple adaptations include those programs that allow learners to select only the pace at which they proceed, as well as those programs that select the next instructional step which will be presented to the learner based on his her response to the previous step (Ross, 1984). On the other hand, complex adaptations involve adjusting several instructional variables (e.g., the amount, type, and sequence of information, practice and

feedback) in accordance with several learner variables (e.g., previous knowledge, current performance, and expressed interest) (Tennyson, Christensen & Park, 1984)

The incorporation of feedback in CAI is regarded as one of the most important instructional components to be considered in the design and development of instructional software. Its exclusive purpose is to provide the learner with information on the correctness of his/her response and increase efficiency in learning of the lesson content. The process involves the learner responding to a prompt, a computer initiated action demanding user input. The learner's response is then compared to the correct response contained in the CAI program code. Usually, the computer feeds back a "canned" message (predefined in the program code) to the learner regarding what he/she did and why it was right or wrong. The type (e.g., corrective, immediate, etc.) and content (e.g., hint, explanation, etc.) of feedback message may depend on several factors such as content area, task domain, learning outcome, instructional objective, and developmental level.

The CAI program compares the student's response to the "canned" responses contained within the program code of the CAI lesson. Furthermore, the feedback process attempts to minimize the learner's response variation by providing the learner with the most appropriate feedback message, thus redirecting the learner towards the ideal instructional path. Based on predefined feedback "algorithms" programmed by the CAI author, the lesson will either loop back to the same item, branch to the next instructional sequence or continue the instructional sequence without referring back to the incorrectly answered item.

Computer-Based Adaptive Instructional Systems

A computer-based instructional system's adaptiveness is related to certain characteristics associated with the computer's interactive capacity for moment-to-moment analysis and adjustment (Tennyson & Park, 1984).

The general goals of adaptive instruction include the implementation of diagnostic and prescriptive instructional management systems designed to make the learning experience more efficient, meaningful, and productive for the student; and instructional management systems that

accommodate individual learning need to facilitate acquisition of defined objectives (Tennyson & Park 1984)

The characteristics of adaptive instruction include (1) initial diagnosis and prescription, (2) iterative updating of the diagnosis and prescription, (3) criterion means for controlling amount of instruction, (4) sequence of instruction based on response-sensitive decision rules, (5) procedures for controlling instructional time, and (6) advisement strategies for learner participation in the instructional management (see Tennyson & Park, 1984)

The Minnesota Adaptive Instructional System (MAIS), developed by Tennyson and Rothen (1979), is an adaptive system determining the optimal amount of practice The algorithm used to adapt instructional sequences is based on prior knowledge, criterion level of performance and a "loss ratio" reflecting losses associated with advancing the learner whose true level of functioning is below the criterion and retaining a learner whose true level exceeds the criterion (Tennyson & Rothen , 1979). The model is continuously updated with each learner response It can be used to determine the amount of practice an individual receives (adaptive control) or to advise the learner, who has control over amount of practice, on how best to achieve the learning objectives

A critical factor is the provision of advisement or suggestions on how to exercise learning successfully or when to do it. Advise such as this has included the optimal amount of practice needed, how a student's performance compares to program criteria, and how and when to use learner control (Kinzie, 1990).

The Bayseian probabilistic model, included in MAIS, is a strategy designed to adjust continuously an instructional treatment according to a student's on-task learning needs after an initial assignment of a treatment according to the student's learning characteristics (pretask measure) (Rothen & Tennyson, 1978) According to Tennyson and Rothen (1979) the application of Bayes's theorem of conditional probability seems appropriate in an adaptive instructional system because of the need to diagnose a student's existing knowledge and to determine the probability of mastery for the new learning task The probability of learning a given

task is used in prescribing an initial instructional treatment The probability figure can be adjusted (from on-task performance data) during the student's actual learning of the task This strategy uses both pretask and on-task data, which allows for continuous updating of a probability value, and results in a constant control over the instructional process.

Intelligent Tutoring Systems (ITS)

Feedback principles are central components in current intelligent tutoring systems (ITS) or intelligent computer-assisted instruction (ICAI). For an ITS to be called "intelligent" depends mostly on its ability to conduct on-line diagnoses and modeling of the learner (Fischer & Mandl, 1988) According to Wexler (1970) the former CAI systems were *ad hoc* frame-oriented (AFO) because the responsiveness of the learning device was restricted to a fixed event space anticipated at the time of system construction. Recent ITSs, however, are flexible with respect to a wide range of unforeseen events Their flexibility, which is often equated with their "intelligence", is based on their ability to diagnose and to capitalize on each student's failure as an opportunity to correct a misconception (Rickel, 1989) Koffman and Blunt (1975) define intelligence of a system according to how well the system is able to reconstruct and hypothesize the sources of difficulty for a given learner from a learner's recent learning history within the system Intelligent instruction resides in the ability to analyze and to map precisely the problem the learner is confronted with To estimate the hypothesized distance between the learner's current state of understanding and the ultimate expert knowledge, a valid model of the learner's present state is required This is achieved through diagnostic tasks and questions and retesting to produce a valid noise-free model of the learner A series of diagnostic questions should lead to both overt feedback (tutorial intervention) and some portion of covert feedback from the learner ("I could answer the question put to me"). Systems employing a variety of obtrusive approaches in diagnosing the learner (Barr & Feigenbaum, 1982) include Socratic dialogue techniques, systems with bug-or failure diagnosis overlays, coaching systems, and systems with "mixed initiative" interactions that differ and vary in their degree of obtrusiveness

The Functions of Feedback in CBE

The function of feedback according to Sales (1988), is to help the learner employ a correct learning strategy so that the desired cognitive, behavioral or attitudinal change can be achieved This is accomplished by the presentation of post-response signals that are informational, motivational , or a combination of both. Therefore, feedback refers to the post-response communication with the learner for these purposes (Sales, 1988)

Motivational Feedback

Some, but not all, students are motivated by rewards for correct responses Feedback has to be valued by students in order to be motivating Feedback can motivate students by providing encouragement when learning is difficult for them Lepper and Chabay (1985) reported two categories of motivational feedback in CBI One category is **commiseration**, which is frequently accompanied by attributing the child's performance to external factors (e g , "This is sure a hard one, isn't it?"). The second category is **encouragement**, ("You almost have it") The effects of these kinds of motivational feedback are not known for CAI or any other instructional mode (Steinberg, 1991).

Motivational feedback attempt to influence the learner's behavior in a lesson by providing incentives for correct learner behavior or deterrents for undesirable behavior (Sales, 1988) and the motivational aspects of feedback seem to be highly personal and vary amongst learners (Wager & Wager, 1985).

Sales (1988) proposes a different categorization of motivational feedback based on its value.

Positive motivational feedback used in CBI includes pleasing animated graphics, computer-generated music, or the opportunity to play a computer game (Sales, 1988) The incentive should not be so desirable that it interferes with learning The developmental level of the learner must be taken into consideration when designing positive motivational feedback The motivational effectiveness of positive feedback depends to a large extent on how desirable the learner perceives the incentive to be

Negative Motivational Feedback is used to discourage a learner from repeating an error or from displaying an inappropriate behavior. Its administration in a CBI lesson may include the presentation of text and graphic displays, sounds and loss of points (Sales, 1988). Its effectiveness depends on the learner's perception of its undesirableness

The optimal effectiveness of both motivational feedback, negative and positive, requires the immediate presentation following the learner's response (Brophy, 1981)

Informational Feedback

The second function of feedback is to provide additional information The nature of the feedback message can vary on a continuum from simple to complex. It may simply tell the learner that his/her response is correct or wrong, it might include the correct response, a hint to facilitate the generation of his/her own correct response, a detailed explanation of the correct response, and/or a statement about why the learner's response is wrong.

The feedback message should focus on correcting the misconception represented by the particular answer choice or provide the necessary information to allow the student to correct the misconception (Wager & Wager, 1985) Anticipating common errors and creating appropriate feedback and remedial sequences should facilitate learning Informative (corrective) feedback operates in one of two ways following a response (1) it informs the learner that the answer is correct or accurate and (2) corrects his/her if the answer is wrong and allows the learner to correct himself/herself.

Cognitively, the first function is important because it tells the student an error has occurred so he/she can engage in corrective activity The second function, informational feedback, identifies and corrects the error or provides the learner with enough information to help the student locate and formulate an alternative response (Cohen, 1985).

Informational feedback has the greatest effect after a wrong response (Sales, 1988; Wager & Wager, 1985) Feedback after a correct response is not as important or facilitative in an instructional program

What Constitutes Effective Feedback?

Effective feedback should be response contingent and understood by students (Friend & Milojkovic, 1984; Steinberg, 1991, Stevens, Collins, & Golding, 1982) Response contingency refers to feedback that is specific to the nature of the response For example, if the error is a misspelling rather than content, then the feedback message should address that problem for example, "Correct name, but misspelled"

Attuned to cause of error

It is one thing to determine that a learner made an error, and quite another to determine the underlying causes of that error. That is why at the surface level feedback may correct the response but not the reason for it. Ideally, feedback should respond at this deeper level, addressing underlying mechanisms (Steinberg, 1991) This ideal has not yet been achieved, even by developers of ITS. For example, Anderson, Boyle, Farrell and Reiser (1985) report that when students try to prove geometry theorems, they sometimes makes inferences that are logically correct but that do not lead to problem solution Unfortunately, in such cases Anderson's intelligent tutor does not understand why the student does not solve the problem

Developers of the WHY system which teaches climatology (Stevens, Collins, & Golding, 1982) encountered a similar difficulty The system could only provide feedback at a superficial level, telling the learner what the process should be, when the student gave the wrong step in the process, but it could not determine why the student failed to integrate concepts Unlike a human tutor, it could not help the student overcome basic misconceptions

Role of response confidence

The value of feedback may be related to the student's level of confidence in his/her response According to Kulhavy (1977), a student would probably give superficial attention to the feedback message if he/she is quite certain that he/she has given the correct answer Conversely, if the student is quite certain that his/her answer is wrong then he/she may examine the feedback message more carefully

Commensurate with developmental level

Steinberg (1980b) found that grade one students did not benefit from feedback because they did not know how to use it The ineffectiveness of feedback was related to the students' inability to understand how to use this type of information.

Types of Feedback

Sales (1988) provided a classification of feedback types according to their characteristic and function The list is presented in ascending order of complexity, based on the level of complexity each provides

Feedback Type	Description
No Feedback	The learners progress through the instructional sequence without any indication as to the correctness of their responses.
Knowledge of Correct Responses (KCR)	This type of feedback presents feedback only when a correct answer is given.
Knowledge of Incorrect Results (KIR)	This type of feedback provides feedback to the learner only after an incorrect response.
Knowledge of Correct and Incorrect Response (KR)	Informs learners of the correctness of each of their responses
Knowledge of Correct Response and Knowledge of Incorrect Response with the Correct Response Given (KRw/CR)	When a correct answer is entered, the learner is informed that it is correct. When the response is incorrect, the learner is told of the error and is supplied with the correct answer
Knowledge of Correct Response and Knowledge of Incorrect Response with the Correct Response and an Explanation Given (KRKw/CR & E)	It functions like (KRw/CR) with the addition of an explanation
Knowledge of Consequence (KC)	Informs the learner of the results of an action without being judgmental.

In contrast, Schimmel's classification is based on the amount of information provided to the learner (Shimmel, 1988)

Confirmation Feedback

This type of feedback confirmed the correctness of the learner's response Examples, included, "RIGHT" or "WRONG" Some programs beep or offer verbal feedback only after correct answers or only after incorrect answers.

Correct Response Feedback

This type of feedback presents the correct answer and could be joined by confirmation feedback. For example, "You are wrong The capital of Canada is Ottawa In some programs the confirmation feedback is not explicit Correct response feedback includes the provision of correct answer only after forcing the learner to infer whether their answer is correct At times it is only given after wrong responses

Explanatory Feedback

Explanatory feedback has differed in the extent of the explanation given after a wrong answer. In "specific review", a step-by-step solution to an incorrectly answer question is shown with the exception of the final step "General review" feedback contains summary statements of the instructional content that preceded the learner's wrong answer (Merrill, 1965; Merrill & Stolurow, 1966). Attribute-isolation feedback reviews the attributes of a concept on which the student made an error (Merrill, 1985) Kulhavy (1977) described various types of feedback information content that ranged from simply confirming whether a learner's answer was correct or incorrect to explanations so lengthy that they encompassed remediation

Bug-related Feedback

A "bug" is a systematic error in the learner's understanding of a procedure The explanation in this type of feedback is aimed at correcting the learner's faulty mental model of a procedure Therefore, this type of feedback does more than simply state the correct answer For example, it might actually take the learner through the steps involved in the subtraction of two digit numbers (Brown & Burton, 1978) Bug-related feedback has been employed mainly in ICAI systems such as Anderson and Reiser's (1985) system which taught programming skills These systems are characterized by the compilation of the programming rules and a detailed

"bug-catalogue" which represents potential errors. The student's performance is continuously monitored and compared to the expert's performance When a student's error matches a bug in the catalogue, then bug-related feedback is presented

Bangert-Drowns, Kulik, Kulik, & Morgan (1991) have distinguished feedback by its **content** Kulhavy and Stock described feedback content by three indices of information content. ***load***, the total amount of information given in the feedback from simple yes-no statement to fuller explanations. ***form***, the structural similarity between the information as presented in the feedback message compared to the instructional presentation, and, ***type of information*** whether feedback restates information from the original task, refers to information given elsewhere in the instruction, or actually provides new information.

Kozma and Bangert-Drowns (1987) proposed to distinguish feedback types by their **operation** error correction, presentation of prototypic responses, display of consequences of responses, and explanation of the appropriateness of responses.

Theories of Feedback

> Any theory that depicts learning as a process of mutual influence between learners and their environments must involve feedback implicitly or explicitly because, without feedback, mutual influence is by definition impossible Hence, the feedback construct appears often as an essential element of theories of learning and instruction (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991, p. 214).

Behavioristic Model of Feedback

Reinforcement theory views learning as the formation of stimulus-response (S-R) bonds (Skinner, 1968) Behaviorally-based CBI is characterized by small, complete lesson units, controlled lesson sequences, and discrete, discernible steps The rationale is to divide the learning material or tasks into smaller units and provide immediate feedback so at to ensure the probability of successful response

The appeal of feedback-as-reinforcement idea diminished as information-processing theories were adopted and studies began to provide little evidence that feedback after positive responses acts in a reinforcing manner (Anderson, Kulhavy, Andre, 1971; Bardwell, 1981;

Barringer & Gholson, 1979; Kulhavy, 1977, Roper, 1977) As a consequence a new view of feedback was developed, one which viewed feedback as providing corrective information (Mory, 1989)

According to Mory (1989) feedback acting as reinforcement would be an example of an open-loop, in which operating activity of the system is not affected by input information In this type of system, errors are ignored and attention is paid only to correct responses Thus the operant approach does not provide any way to correct errors. In the feedback-as-information position, a closed-loop system, error detection is of primary importance since the system has ways of correcting them

Cognitive Models of Feedback

Kulhavy and Stock Model (1989)

Kulhavy and Stock (1989) have proposed an information-processing theory based on control theory (Powers, 1978) which makes predictions regarding how the certainty state of the learner interacts with feedback during an instructional sequence The central theme of the theory is the role of response certitude as the determinant of instructional behavior Response certitude results from a metacognitive judgment concerning whether or not a given piece of information is accessible to the learner at the time the judgment is made (Kulhavy, Stock, Hancock, Swindell & Hammrich, 1990)

The model of feedback consists of three cycles. In the first cycle, the learner is presented with a unit of instruction and produces an instructional response after comparing the task with the cognitive referents in long-term memory The response is accompanied by a response certitude the learner's certainty regarding the correctness of the response In the second cycle, the learner compares the feedback message with available cognitive referents which now include the memory trace of the initial response and associated certitude During this second cycle, a response is defined as any learner behaviors exhibited following feedback including studying the feedback message or looking back at the text In the third cycle, the original task is presented again and is compared with the new set of cognitive referents, now

modified by information received from the feedback message The learner again, selects a response and estimates his/her certitude

The response certitude serves as an index of perceived comprehension and as such reflect the learner's ability to relate new information to prior knowledge

According to this model the feedback message possess two functions: (a) verification and (b) elaboration (Kulhavy, Stock, Hancock, Swindell, Hammrich, 1990). First, a dichotomous match between a response and the feedback message leads to a verification component of feedback, correct or incorrect This verification is combined with the original response certitude to yield a measure of discrepancy (Peterson & Swindell, 1991) A central conjecture of the model is that the learner will work to reduce the discrepancy resulting from the comparison process. Little discrepancy exists when high certitude (learner perceives own answer to be correct) and feedback message verifies the correctness of answer Conversely, if the learner has high confidence in his her response but finds out during feedback that he/she is incorrect, discrepancy is at a maximum All additional information contained in the message forms the elaboration component of feedback and is hypothesized to serve a strictly informational function.

Bangert-Drowns, Kulik, Kulik, and Morgan (1991) model

A compilation of previous research has led Bangert-Drowns and colleagues (1991) to the development of a five stage model of feedback based on the state of the learner as he/she proceeds through the feedback cycle. The stages consist of: (1) the learner's initial state, (2) the search and retrieval strategies the learner activates, (3) the learner's response, (4) learner's evaluation of the response, and (5) the adjustments the learner makes. This model emphasizes the construct of "mindfulness", in which activities are exactly opposite of automatic, overlearned responses Feedback can enhance learning if it is mindfully received. However, it can also inhibit learning if received mindlessly, as when a learner is allowed to see the feedback message before responding (pre-search availability) or if instruction is too easy or redundant.

The Relative Importance of Immediate and Delayed Feedback in CBE

Immediate Feedback

Immediate feedback is typically provided during a CBE interaction irrespective of the potential benefits of delayed feedback as documented in increasing evidence from both contemporary cognitive research as well as in behavioral reinforcement (Hannafin & Rieber, 1989a)

Empirical evidence has demonstrated that low-level mastery of subject matter, short-term retention, acquisition of knowledge in the cognitive domain and initial acquisition of novel instructional material is facilitated by immediate feedback (Bardwell, 1981, Cohen, 1985, Gaynor, 1981; Roper, 1977).

Level of mastery of the student, i.e., the grasp of the material exhibited by the student during the presentation of the lesson, appears to have an effect. If the student exhibits low mastery of the subject matter then providing immediate feedback seems to facilitate learning because the learner is receiving help or information as he/she is interacting with the lesson (Cohen, 1985)

Immediate feedback has been shown to facilitate short-term retention and initial acquisition (Bardwell, 1981; Gaynor, 1981) It also seems to facilitate the acquisition of knowledge in the cognitive domain (Bloom, 1976). In summary, factors such as the goals of the instructional unit must be taken into consideration when selecting immediate or delayed feedback Also, if the instructional goal is initial acquisition of content, or the recognition or immediate recall of ideas then immediate feedback is desired (Cohen, 1985)

Roper (1977) seems to indicate that immediate feedback facilitates learning when the student has no prior knowledge of the content If subjects do have prior knowledge of the content then it seems better to delay the informational feedback while still presenting KR immediately after each students response (Roper, 1977) The immediate KR would locate errors in the student's mind but it would also delay the message that would help correct the errors

Should feedback be immediate?

A key principle in the behavioral approach to instruction is the provision of immediate feedback Immediate feedback is reasonable if it is synonymous with reinforcement, because it would strengthen the probability of a correct response and diminish the probability of an incorrect one If the role of feedback is informative, then there is no reason to provide immediate feedback

A paradox exists in the literature between two psychologists and their views on the immediacy of feedback R C Anderson and colleagues (once behaviorally oriented) demonstrated that not only is immediate feedback not essential but in some cases it might also be detrimental (Kulhavy & Anderson, 1972). On the other hand, J R. Anderson, a cognitive psychologist, advocates the importance of immediate feedback to correct errors in his ITS (Anderson, Boyle, & Reiser, 1985)!

R C Anderson notes that in a test situation, immediate feedback strengthens tendencies After a delay, a student forgets the response he/she gave on the initial test. Error tendencies interfere with learning the correct answers when feedback is immediate. Consequently, there is more preservation in immediate feedback In addition, students who get delayed feedback also take longer to study than the ones who receive immediate feedback

J. R Anderson provides immediate feedback in his geometry tutor He asserts that it is difficult for a student to find and correct errors if he/she makes an error in his/her proof and then continues with a series of steps based on that error until he/she hits an impasse The student may be overwhelmed by information overload as he/she tries to backtrack and recover from his/her errors Furthermore, delayed feedback may promote learning incorrect procedures Also, immediate feedback may prevent frustration when students are engaged in complex problem-solving tasks

The differences between these two researchers lies mainly in the different subject matter addressed and the differences in the nature of the tasks One body of research involves mathematics (geometry), the other prose materials The geometry involves skill learning in a

tutoring situation, while the prose materials involves testing and overcoming previously acquired errors. The purpose of feedback is also different The geometry tutoring system expects students to learn to do geometry proofs in a certain preset way The intent is to prevent students from getting lost, wasting time and feeling frustrated. In the studies involving prose materials, feedback serves to assist students to overcome previously acquired errors

Immediate Feedback An ITS example

The policy of immediate feedback is well represented by the LISP tutor The LISP tutor insists that the student stay on the correct path and immediately flags errors. This, according to Anderson, Boyle, Corbett and Lewis (1990), minimizes problems of indeterminacy First, there is psychological evidence that feedback of an error is effective given that it is provided in close proximity of the error (Anderson, Kulhavy & Andre, 1972, Lewis & Anderson, 1985). Apparently, it is easier for the student to analyze the mental state that led to the error and make the appropriate correction Secondly, immediate feedback makes learning more efficient because it avoids long episodes in which the student flounders through incorrect solutions Thirdly, it tends to prevent the extreme frustration that accumulates as a result of many unsuccessful attempts in an error state.

Problems associated with immediate feedback

Anderson, Boyle, Corbett and Lewis (1990) have documented explicitly the problems they have encountered in using immediate feedback in their ITS These problems include

(a) The feedback has to be carefully designed to force the student to think. The feedback should force the student to calculate the correct answer rather than just provide the answer (Anderson, Kulhavy & Andre, 1972). The important issue for learning, is the student's active involvement in the thought processes that generate the answer

(b) Sometimes students would have noticed their errors and corrected them if given more time

(c) Students find immediate correction annoying This is particularly true for more experienced students Anderson, Boyle, Corbett and Lewis (1990) have found that novice

programmers generally appreciated the immediate feedback feature of the LISP tutor whereas experienced programmers did not

(d) Often it is difficult to explain why a student's choice is wrong at the point at which the error is first manifested because there is not enough context In the LISP tutor, for example, it is easier to explain the choice after the complete code has been generated rather than when a single command is typed

The current tutors treat all errors as if they reflected fundamental misconceptions and offer detailed explanations For example, if the student has a past history of success on a rule it is more likely that error reflects a slip, rather than some fundamental misconception (Anderson, Boyle, Corbett and Lewis, 1990) In other words, "if students make an error we give the same feedback independent of their history" (Anderson, Boyle, Corbett and Lewis, 1990, p. 39).

According to Anderson, Boyle, Corbett and Lewis (1990) the designer should base decisions on a careful analysis of instructional goal and target audience and there is no reason why a combination of both immediate and delayed feedback, should not be incorporated in the instructional unit

Delayed Feedback

If the student exhibits a high level mastery of the content, then delayed feedback (e.g., End of Session, EOS) presented at the end of the lesson would be beneficial in assessing the student's progress (Gaynor, 1981) It seems that immediate feedback in a high level mastery situation impedes the pace of learning and progression through the material (Cohen, 1985)

Delayed feedback (e.g , EOS (Gaynor, 1981)) seems to facilitate long-term retention, especially with high mastery students. EOS has also been shown to facilitate learning when students are working with information at the comprehension application level of Bloom's Taxonomy This type of feedback seems to serve as an organizer that allows students to readjust internal misconceptions if enough information is provided via the feedback message.

The Use of Confidence Levels to Determine Timing and Content of Feedback

One of the biggest challenges in interactive technology is the provision of information

feedback to the learners concerning the correctness or adequacy of their responses (Nelson, Wernikoff & Moore, 1990)

According to Hannafin and Rieber (1989b), both questions and feedback influence the quality of cognitive engagement and subsequent strength of encoding Feedback effect is mediated, to a large extent, by the learner's confidence while responding It is most effective for incorrect responses with high confidence, but it is relatively inconsequential for correct response with high confidence. For both correct and incorrect low-confidence responses, all but informative feedback are of little value (Kulhavy, 1977)

Confidence levels may provide a measure that can be used to determine the type and amount of feedback appropriate to the learner (Nelson, Wernikoff & Moore, 1990) There are four possible scenarios regarding the relationship between response status and certitude level The four possible scenarios regarding correctness/incorrectness and level of confidence include the following: when correct and confident in their answer allow the learner to proceed with minimal feedback. When correct and lacking confidence, feedback would provide some brief statement as to why it is correct. When incorrect and confident in the incorrect answer, feedback would indicate the error and provide detail as to the correct answer and its basis When a learner is incorrect and lacks confidence, reflecting a not-knowing state would require a detailed explanation of the correct answer and its basis (Nelson, Wernikoff & Moore, 1990)

Dempsey and Driscoll (1989) have speculated about the reliability of self-reported confidence measures among sophisticated learners versus learners with less ability and older versus younger learners

Matching Feedback to Desired Learning Outcomes

Cognitive Strategies

Instruction regarding cognitive strategies involve the development of techniques for manipulating information The best candidate for this type of learning outcome would be knowledge of consequences since it requires the learner to think through the instructional sequence. The use of KC in combination with other types of feedback may be appropriate

(Sales, 1988)

Intellectual Skills

The intellectual skills category can be divided into: **Higher level** outcomes (i e., problem solving, rule learning and defined concepts) which require the learner to solve problems. This type of learning involves the formulation, refinement and testing of hypotheses and as such elaborative feedback may be more useful since it provides explanations of errors and use of KRKw/CR & E may be most effective **Lower level** outcomes (i.e., concrete concepts and discriminations) require the learner to identify and discriminate between members of a specific class (Briggs & Wager, 1981; Dick & Carey, 1989) Less elaborate feedback (KR) that simply informs the learner would suffice (Sales, 1988). Schimmel (1988) proposes that learner-controlled feedback of varying content information should be made available for high-ability students since they usually indulge in self-regulated learning (Corno & Mandiach, 1983) and can allow them to select the appropriate information required Furthermore, only one method of feedback that increased learning of intellectual skills consisted of identification of the error, guidance toward correction, and praise for aspects of work well done (Schimmel, 1988). This type of combination feedback seems more applicable to an ITS than CAI.

Verbal Information

The learning outcome of verbal information is correct identification which encompasses organized information, facts and labels Learners usually have to state their response and as such simply KIR or KR is useful (Sales, 1988) According to Schimmel's (1993) meta-analysis on the use of feedback in CBI and PI, confirmation or correct response feedback seems more suited for verbal learning tasks

Attitudes

Three most common techniques to modify attitudes are persuasive information, human modeling and positive reinforcements (Sales, 1988) The computer medium lends itself well for the presentation of persuasive information and human modeling. Learners may need information if they do not perceive some aspect of the instruction. As such the most complex and elaborate

types of feedback (KR w/CR, KR w/CR & E, or KC) offer learners the explanations they might require to examine the consequences of their actions (Sales, 1988)

Motor Skills

Motor skills range from simple to complex tasks. Simple tasks (e.g . flicking a switch) requires very simple KIR, whereas tasks involving complex manipulation may requires more elaborative feedback that constantly informs learner of their progress (Sales, 1988).

Procedural Instruction

The use of bug-related feedback is better suited for procedural instruction such as solving algebra problems The development of "bugs" is difficult and tedious work involving extensive formative evaluation of bugs from the target audience (Anderson et al., 1985). In addition, difficulties in developing bug-related feedback include the identification of bugs and the feedback required to correct bugs The identification of a bug is difficult because an error might represent the product of many bugs or mere carelessness Furthermore, even if the bug catalogue is constructed, the instruction required to correct the bug may be beyond the scope of feedback .

CBE Development Guidelines

There are few guidelines for the development of feedback in CAI that are substantiated by sound empirical data (Alessi & Trollip, 1985, Bardwell, 1981, Friend & Milojkovic, Gaynor, 1981; Jonassen, 1988; Rickel, 1989; Schimmel, 1983; 1988, Wager & Wager, 1985) Many of the guidelines are "heuristics" based on practical knowledge and experience of instructional designers, teachers and users

General Guidelines

(1)Effective feedback is response specific (providing information directly aimed at the error) so the learner has the opportunity to correct the answer.

(2)Avoid feedback that is ambiguous of misleading

(3)Place the feedback on the screen below the input so that it is noticeable to the learner If the answer is incorrect, this will facilitate the comparison

(4)Keep the question, student response and feedback message on the same screen

(5)Draw attention to feedback by underlining parts of the question and response The highlighting techniques will allow a student to focus on specific attributes and hence correct any misconceptions.

(6)Avoid rewards that are time-consuming For example, the use of sound and graphics distracts the learner and others around them.

(7)Provide summary feedback over a series of or patterns of responses.

Feedback After Correct Responses

(1)A simple statement of confirmation after a correct response is sufficient. Elaborate feedback after a correct response is meaningless and slows down the pace.

(2)Reinforce the correct answer by placing it in a sentence or problem Long-term retention may be enhanced by the viewing of the correct answer in the context of a sentence or problem

(3)Provide feedback for answers that are partially correct; include information that will allow the student to format their answers correctly.

Feedback After Incorrect Responses

(1)Provide feedback for anticipated wrong answers that tells learners exactly why their answers are wrong. Simple directive type feedback is more effective than a "blanket" type message (e.g., "No, you're wrong" or No, try again") Programmers should purposely use multiple choice questions so as to limit possible responses and provide corrective feedback for each incorrect alternative

(2)Avoid wrong answer feedback that is entertaining or novel.

(3)Provide increasingly informative feedback after each successive wrong answer.

Review of the Literature

Anderson, Kulhavy and Andre (1971) conducted two experiments investigating the effects on knowledge of correct results (KCR) feedback on student achievement. One hundred

and sixty eight (168) university students enrolled in a summer educational psychology course were stratified according to verbal ability and then randomized to eight feedback conditions 0%-KCR (no KCR presented after each frame), 100%-KCR (KCR presented after every frame), KCR-R (KCR was presented after correct answers only), 10%-KCR-R (KCR was presented after a random 10% of correct answers: no KCR given after wrong answers) KCR-W (KCR was presented after wrong answers only), Time-Out (KCR was presented after wrong answers following a 15 seconds interval with the frame in view), Correct (KCR was provided after each correct answer) and Voluntary (after responding the subject voluntarily selected KCR or no KCR) The content of the computer-based instructional system included the diagnosis of myocardial infarction from electrocardiograms presented in the form of diagrams, ECG tracings and tables. Subjects were required to respond to either multiple choice or completion question Results indicated no significant differences on the immediate criterion test among feedback procedures

A second experiment by Anderson, Kulhavy and Andre (1971) was performed to test the hypothesis that KCR is facilitative only when students cannot peek (pre-search availability) at it before responding. One hundred and sixty seven subjects (167) enrolled in an educational psychology class were randomly assigned to six feedback groups· 0%-KCR (no KCR presented after each frame), 100%-KCR (KCR presented after every frame), Forced (KCR was presented immediately after each frame and after an error he/she was forced to repeat frame), Review (KCR was presen'ed immediately after each frame and after an error he/she was forced to repeat frame while subsequent errors were followed up with remediation), Time-Out (KCR was presented after each frame exposed or a fifteen second time-out with the frame text and KCR in view after an error) and Peek (KCR was presented at the same as the frame was exposed) and one control group A physician and programmer modified the original frame-based computerized lesson on myocardial infarctions and criterion test The 100%-KCR groups outperformed the 0%-KCR group on retention test administered fourteen to sixteen weeks following the experimental sessions.

Anderson, Kulhavy and Andre (1972) conducted a subsequent study to test the

hypothesis that feedback failed to show advantage because programs used in these studies contained many copying frames and were otherwise heavily prompted One hundred and nineteen (119) volunteers enrolled in an educational psychology class participated to fulfill a course requirement They were randomly assigned to five conditions from within three verbal ability strata. The experimental conditions were as follows 100% standard (feedback presented after every frame), 0% standard (no feedback after every frame), peek standard (feedback continuously in view), 100% copying group (received feedback following each frame) and 0% copying (no feedback following each group) The lesson content consisted of an adapted version of a programmed introduction to population genetics The paper-and-pencil criterion test consisted of two short answer items and thirty-one four-alternative multiple choice questions which required the students to apply a concept or principle to an example different from any contained in the program Results indicated that the 100% standard group performed better than the 0% standard group but the difference was not statistically significant

Armour-Thomas, White and Boehm (1987) compared three types of computer-generated feedback on children's learning and retention of relational concepts Three feedback conditions were presented and were characterized as textual KR (knowledge of results), symbolic KR and pictorial KR The children's level of knowledge of basic relational concepts was measured using immediate and delayed posttests Results indicated that there were no significant differences among the feedback conditions indicating that feedback type did not differentially affect concept acquisition

Arnone and Grabowski (1992) conducted a study to evaluate the effectiveness of variations of learner control on children's level of curiosity and achievement from a computer-based interactive video (CBIV) The content consisted of "a visit to an art museum" and included both facts and concepts Opportunities were provided for practice, feedback and remediation. The presentation was a combination of motion video, slides and computer graphics Three treatments were developed which varied the amount of leaner control over the lesson· program control, learner control and learner control with advisement Subjects in the program control

lesson followed a linear path through the lesson while receiving practice items feedback and were automatically branched to a remediation segment after a second incorrect response In the learner control lesson, subject were given control over sequencing, pacing, stopping, remediation and exiting. Subjects in the learner control with advisement condition were given the same control over the lesson and provided with certain advisement strategies that provided guidance and encouraged curiosity. For example, a subject who decided to skip a section would receive this advisement: "Are you sure you want to end the lesson? This section is very interesting You might really enjoy it" An achievement posttest consisting of eight previously unencountered open-ended questions was administered immediately after the lesson Post-hoc analyses resulted in a significant difference between the learner control and the learner control with advisement groups. In this comparison, the learner control with advisement groups scored significantly higher that the learner control group

Bumgarner (1984) investigated the effects of microcomputer statements of informational feedback and of praise on student achievement during drill and practice on multiplication facts by third graders. Three levels of feedback, no feedback (NFB), knowledge of results (KOR) and knowledge of results followed by a corrective procedure (KOR + CP) were crossed factorially with two levels of social reinforcement no praise (NSR) and twenty percent variable percentage variable percentage praise (SR). Subjects in the KOR + CP group either received "RIGHT" or "WRONG" following their answer and in addition to "WRONG" the words "TRY AGAIN" were displayed and the student was required to make a second response to the problem A second incorrect answer resulted in the presentation of the correct answer The KOR groups received either "RIGHT" or "WRONG" as appropriate and proceeded to the next problem Subjects in the no feedback group proceeded through the program without any feedback message Results indicated that the NFB outperformed the KOR group while there was no significant difference between the KOR + CP and control group (NFB) In addition the KOR + CP treatment group outperformed the KOR only treatment group

Chanond (1988) examined the effects of feedback, correctness of response and

response confidence on the learner's retention of verbal information within the context of CAI One hundred and twenty three university students were randomly assigned to either the no feedback or the feedback condition The instructional material included 30 program frames with three alternative multiple-choice questions relating to the structure and function of the human eye. Different feedback messages were provided to subjects based on the correctness of response and response confidence In addition, the feedback messages were written by the researcher and evaluated and criticized by two doctoral students A correct answer followed by a high response confidence resulted in a brief statement of response correctness confirmation statement (e g., "correct"), whereas correct answer with low response confidence provided a message regarding the correctness of the answer plus a sentence emphasizing the relation between the concepts involved in the answer Incorrect answer with high confidence resulted in the presentation of a statement regarding response correctness (e.g., incorrect), detailed response contingent explanation and the correct answer. Furthermore, incorrect answers with low confidence resulted in the presentation of a statement regarding response correctness (e.g., incorrect), response contingent explanation and the correct answer. The overall results indicated a significant difference between the feedback conditions with those receiving feedback performing significantly better than the no feedback group Regardless of the learner's confidence in the response, feedback following an incorrect response had significant effects on both the immediate and delayed retention of the learned material

Clariana, Ross and Morrison (1991) examined the effects of using different forms of computer-based feedback on high school students' learning of science material. One hundred (100) students considered to be at risk academically were randomly assigned to one of ten treatment groups consisting of five feedback conditions (KCR, AUC, delayed KCR), two control conditions (questions only and no questions) crossed with two conditions of instructional support (text and no text) The KCR (knowledge of correct response) conditions informed the learner of the correct response after each answer The AUC (answer until correct) condition provided the same feedback as KCR following correct responses. However, the student was prompted to try

again after an incorrect answer and instructed to type in the letter corresponding to the correct answer following a subsequent error The delayed feedback condition provided KCR-type feedback at the end of all four lesson sections by individually presenting all forty questions with the correct answer Posthoc analyses conducted on the immediate and delayed (retention) posttests of achievement showed significant differences between all three feedback strategies

Elliot's (1986) doctoral dissertation investigated the use of microcomputer displayed feedback to enhance poor readers' comprehension of text The study focused on two comprehension strategies, questions interspersed in text and immediate feedback regarding students' answers to interspersed questions Forty-two students were randomly assigned to three groups: (a)a text-only control group which read computerized text containing neither interspersed questions or feedback (control group), (b)a group that read text containing interspersed questions but which received no feedback, and (c)a group receiving feedback in addition to the interspersed questions Three versions, one for each group, of each passage on science and social science material served as the content for the computerized lessons While in the feedback group, incorrect student responses resulted in the presentation of a short remedial sequence, brief explanation how the correct answer was arrived and related text content Results failed to show any significant differences among the treatment groups on the cloze tests, multiple choice comprehension tests, or inferential and factual question subsets

Gaynor (1981) investigated the effect of a delay in feedback (knowledge of correct results) on the retention of mathematical materials when the taxonomic level (i e , knowledge, comprehension and application) of material and the degree of original learning by the students were considered A total of ninety-two undergraduate students enrolled in elementary business statistic classes took part in the experiment The levels of feedback delay considered, were immediate feedback (IF), 30 second feedback (30 sec) and end of session feedback (EOS) The 30 sec group received knowledge of correct results thirty seconds after responding to an item, but the EOS group worked through the daily lesson before they received knowledge of correct results A control group received no feedback The short term retention posttest was

administered seven days after the experiment followed by a long retention posttest administered a week later There were no significant differences between the feedback groups on all three taxonomic levels (i e , knowledge, comprehension and application) for both short and long retention tests Although not significant, immediate feedback yielded better results than the EOS feedback and 30 sec feedback across all taxonomic levels during short retention administration. Similarly, although not significant, EOS feedback facilitated high mastery of material while immediate feedback (IF) facilitated low mastery across all taxonomic levels during long retention administration

Gilman (1969a) compared several feedback methods for correcting science concepts by computer-assisted instruction. Seventy-five university students were taught thirty general science concepts via program frames in the form of multiple choice items. Five feedback modes used were no feedback, feedback of "correct" or "wrong" (KOR), feedback of correct response choice (KCR), feedback appropriate to student's response (response contingent) and combination of KOR, KCR and response contingent. An analysis of posttest means yielded a significant mean difference between all feedback groups Posthoc analyses revealed a significantly higher mean score for the combination group compared to the no feedback, KOR and KCR groups

Gilman (1969b) examined the rate of learning, retention and students' attitude toward instruction as a result of error correction in computer-assisted instruction The type of feedback were no feedback, knowledge of results feedback, knowledge of correct response feedback, response contingent feedback, and a combination of knowledge of results, knowledge of correct response and response contingent feedback The frames of the program were multiple choice items dealing with general science concepts A thirty item posttest, consisted of items presented in the program, designed to measure knowledge of general science concepts was administered immediately following program presentation. Post hoc analyses showed the combination group mean posttest score was significantly higher than the mean of knowledge of results group

Hines and Seidman (1988) examined the effects of immediate, delayed and no feedback

and the type of control (external or internal) on a CAI program covering the definitions and concepts in social science research methodology Furthermore, the effects of computer anxiety, self-concept, learning style and gender were also examined Three hundred and thirty-six (336) university students majoring in speech, communications and psychology were randomly assigned to one of the seven groups. The seven groups were linear program (no embedded questions and no feedback), external control with no feedback (students asked questions and were recycled through the instruction and asked the question again if they answered incorrectly), external control with immediate feedback (same as external control with no feedback but immediate feedback given after student's responses), external control with delayed feedback (same external control with immediate feedback but given feedback regarding the number of correct responses only after the student completed the CAI program. Internal control with no feedback (subjects were asked questions at particular point in the instruction and upon answering a question, they had the chance to continue or go back and see the instruction again if they answered the previous question incorrectly), internal control with immediate feedback (same as internal control with no feedback but with immediate feedback included) and internal control with delayed feedback (same as internal control with no feedback but with delayed feedback included) The results showed no significant difference in achievement for either the control or feedback variables

Hodes (1985) examined the effects of corrective and noncorrective feedback on learning metric conversion Forty-one high school students were randomly assigned to either a corrective or noncorrective feedback group The corrective feedback condition identified the incorrect response as wrong, gave the student a corrective procedure and maintained a supportive encouragement for the student to try again The noncorrective feedback condition identified the incorrect response as wrong, did not provide a corrective procedure nor encouragement to try again and consisted of an occasional "put down" to the student

Results revealed no significant differences between the posttest scores of the treatment groups as measured by an immediate achievement posttest assessing computational ability

Johansen & Tennyson (1983) investigated the proposition that learner control of instruction can be facilitated by directly affecting the student's perception of learning need In instructional terms, perception determines the intensity of cognition that a student applies to the initial process of learning new information (Deutsch & Deutsch, 1963) The MAIS determined the amount of instruction that a given student receives based on a conditional probability procedure calculated from three parameter values achievement level, (number of problem examples correct with number received), learning-program mastery criterion, and a loss ratio. Furthermore, the system used to inform learners after the introductory instruction of their initial level of rule using and advising them on the amount and sequence of instruction necessary for them to obtain the objective The effects of advisement was accomplished by comparing three contrasting learner-control management strategies. For the advisement-learner-control and partial-learner-control, the computer based lessons consisted of two sections. first, an introduction set of practice items presented by program control, followed by a second set of practice items under learner control The second section required the learner to decide whether to continue receiving examples or to go to the posttest, and if to continue, which rule they wanted to see next. The learner-control condition, the computer-based lessons consisted of only one management strategy - complete subject control on amount and sequence of instruction throughout the lesson. The results yielded a significant difference between advisement strategies on three instructional units which involved a rule-learning task. The advisement-learner control group performed significantly better than subjects in either the partial-learner group or the learner-control group.

Roper (1977) attempted to discover the exact locus of feedback action and thus to test the 'response-strengthening' and 'error correcting theories' of feedback The experiment compared the effects of KCR, KR and no feedback examined the effect of immediate feedback in statistics concepts Thirty-six students studying psychology and environmental sciences were randomly assigned to a no feedback, feedback of 'correct' or 'wrong', or feedback of 'correct' or 'wrong' plus the correct answer stated in the context of the question. An examination of the immediate achievement posttest scores, comprised of twenty-five questions similar to those used

in the computer presented teaching program, yielded a significant difference between the groups Post hoc comparisons between group means revealed a significant difference between each feedback groups and the control group but significant differences between the two feedback groups.

Schaeff and Hannafin (1986) studied the effects of systematically varied interactivity on learning from interactive video. Ninety-eight high school students were blocked as high or low in achievement based on their cumulative grade point average (GPA) and then randomly assigned to four experimental conditions and one control condition The interactive video instructional treatments consisted of video, video plus-question, video-plus-question-plus-feedback and fully interactive. The video condition consisted of a linear presentation The video-plus-question condition presented the video, asked factual and thematic multiple choice questions The students received no response feedback, no review of instruction and no additional interaction In the video-plus-questions-plus-feedback condition, students were presented the video, embedded questions and feedback regarding the accuracy of their responses, as well as correct choice for incorrect initial student responses (KR) However, no additional instruction was provided for either correct or incorrect answers The fully interactive condition presented the video, embedded questions and provided students with feedback for correct and incorrect responses, and branched to repeat video segments for which accurate learning was not demonstrated Univariate analyses indicated significant differences between groups and more specifically, students in the fully interactive condition obtained higher recall scores that the video condition and video-plus-question conditions Moreover, recall scores were higher for high versus low ability students

Schloss, Wisniewski and Cartwright (1988) examined the effect of learner control versus program control feedback on the achievement of undergraduate students The CAI modules included discussions of special education topics such as referral procedures, protective safeguards and due process, confidentiality Subjects were randomly assigned to four groups choice loop/no feedback, forced loop/no feedback, choice loop/feedback and forced

loop/feedback The lesson format consisted of information screens and multiple choice test item screens Higher cognitive questions required the students to make predictions, provide solutions explanations and evidence, generalize or interpret using program from the preceding text Following each question, students were prompted to select one of four possible responses. When the correct answer was selected, the word "correct" appeared followed by the next screen of text information. Selection of an incorrect response, provided the learner the opportunity to loop back to the critical text If the student missed the question on the second try, the program advanced to the next screen of information The selection of an incorrect item in the closed loop condition was counteracted with the presentation of information relevant to answering the question When averaged across the two looping conditions students in the feedback condition performed significantly better than those in the no feedback condition.

Tennyson (1980) examined two instructional design variables directly related to concept learning and two forms of content structure used in learning coordinate physics concepts The two independent variables of management strategy (adaptive control, learner control and learner-adaptive control) and content structure (simultaneous and successive) were employed in this experiment The MAIS adaptive instructional strategy was initially used to advise students of their initial concept attainment compared to the desired learning criterion (diagnosis) and the amount and sequence of instruction necessary for them to obtain their objective (prescription) followed by continuous on task advisement of their learning development (updated diagnosis) and the instructional needs (updated prescription) necessary for concept mastery The amount and sequence of instructional material in the adaptive control was program controlled The learner control condition gave students control over the amount and sequence of instruction. In the learner adaptive control, students had control over amount and sequence, and advisement on diagnosis and prescription In this condition, feedback on correctness of concept classification was presented after each example Simultaneous content was presented in rational sets whereas, successive display included separate presentation of concepts Results yielded a significant main effect for management strategies with adaptive control being equivalent to

learner-adaptive and both higher than learner control

Tennyson (1981) conducted two experiments testing the hypothesis that students can effectively manage their learning needs in an adaptive instructional system (MAIS) when provided continuous, updated advisement information about their achievement (diagnosis) and instructional needs (prescription) in relation to the objective The content of the instructional program consisted of 104 examples of coordinate physics concepts (same as Tennyson, 1980) In the first experiment, sixty-three high school students were randomly assigned to three CAI management strategies (learner-adaptive control, adaptive-control and learner-control). In the learner-control treatment conditions, the subjects decided whether to continue receiving examples or to go to the posttest and which concept they wanted to study next In contrast, the adaptive-control condition using the MAIS management system, continuously selected the number of examples presented to each students based on the student's pretest and on-task performance in relation to the learning objective, then sequenced the concepts according to the student's response pattern to each given example The learner-adaptive-control condition allowed students to decide whether or not to continue receiving instruction and advised them on the number of examples needed to reach mastery for each concept (diagnostic and prescriptive information provided by MAIS). Statistical analysis of correct posttest scores indicated a significant difference between the three management strategies Further posthoc analyses revealed that the mean correct score for the learner-adaptive control condition was equivalent to the adaptive control condition, both of which were higher than the learner-control condition

In the second experiment Tennyson (1981) selected a rule learning task and tested the learner control variable over an extended period of learning, when the subjects had become familiar with a learner-controlled management strategy Forty-seven high school students were randomly assigned to one of three treatment groups The learning program consisted of 189 examples of nine internal punctuation rules The learner-control, consisted of one management strategy. complete subject control over the amount and sequence of instruction throughout the entire program The treatment programs for the learner-adaptive and learner-partial-control

conditions consisted of two section: an introductory set of examples presented by program control, followed by a second set of examples presented under learner control The examples in both sections were presented using the adaptive sequence rule of MAIS The results displayed a pattern between the three conditions across three testing periods The descending order of posttest correct scores per conditions were as follows: learner-adaptive-control condition, learner-partial condition and learner-control condition

Tennyson and Buttrey (1980) investigated the effectiveness of advisement and management strategies in CAI One hundred and thirty-nine high school students from psychology classes were assigned to one of four treatment groups Coordinate (e.g , positive reinforcement) and subordinate concepts (e g , stimulus) from the field of psychology comprised the content of the lesson Two independent variables of management (adaptive control and learner control) and advisement (with and without) were tested with a pretest-posttest, two-way factorial design In the advisement condition for adaptive control, students were informed, following the pretest and after each response, of the number of examples needed to reach mastery (diagnosis and prescription information provided by MAIS) Program direction for the adaptive control condition informed the students that advisement was determined according to their individual learning development in relation to mastering the concepts The adaptive control condition without advisement did not provide students with information on their learning progress; nor did the learner-control without advisement provide students with diagnostic help Posttest score analyses indicated a significant difference between advisement strategies, with the group receiving advisement having higher scores than the groups receiving no advisement

Problem Statement

Feedback can have both motivational and cognitive outcomes in any learning situation. Despite the wide acceptance of feedback in CBE, empirical support for particular types of feedback have been inconsistent and contradictory Despite the acknowledged effects of feedback in the learning process, the effects of feedback on learning and retention are still largely unclear (Wager & Wager 1985) After more than a decade of research, there is no definitive information

regarding how feedback form or content affects learning (Kulhavy, 1977) Very little research has guided our use of feedback and there are very few practical suggestions on how to use feedback (Cohen, 1985). The optimal content of the feedback message is still in question (Schimmel, 1988) Despite widespread acceptance of feedback in CBI, empirical support for particular types of feedback information has been inconsistent or weak (Schimmel, 1988). Research guides little direction on the use of feedback (Schimmel, 1988). There are still many areas in which the literature on feedback is inconsistent, and yet other areas that have been left unexplored (Mory, 1989).

The aim of the following study was to conduct a meta-analysis pertaining to the research literature on the effects of feedback on learning in CBE More specifically, to discern empirically, which types of feedback will increase learning efficiency under specified conditions The rapid increase and proliferation of contradictory and inconsistent empirical findings on the effects of different types of feedback in CBE impedes the proper synthesis of the literature A meta-analytic review in this area of research could help direct future research more efficiently, increase the knowledge base concerning the effectiveness of different types of feedback and disseminate scientific information to wider audiences Such a study may conceivably clarify the differential effects of various types of feedback utilized CBE.

METHOD

Meta-Analysis

A quantitative and qualitative meta-analysis of the literature on the effects of computer-presented feedback on learning from computer-based instruction (CBI) was conducted Numerous meta-analytic procedures (Hedges & Olkin, 1985, Hunter & Schmid, 1990; Rosenthal, 1991) were used to synthesize empirical studies gathered during data collection. The overall quantitative meta-analytic approach (see Appendix A) involved the following procedures (a) data collection (acquirement of studies), (b) creation of inclusion criteria, (c) development of a coding scheme and subsequent separate analysis based on studies involving immediate posttest administration and those involving delayed posttest administration including (e) calculation of effects sizes, (f) calculation of unbiased estimators of effect sizes, (g) calculation of average effect sizes, (h) calculation of average weighted effect sizes, (i) calculation of heterogeneity of effect sizes, (j) calculation of frequencies and means for all categories across each study variable, (k) calculation of one-way analyses of variance between all categories across each study feature, and (l) performance of a multiple regression analysis on particular study features in studies involving immediate posttest administration

The qualitative meta-analysis (see Appendix A) portion of the study involved an: analysis and discussion of salient methodological features of studies rejected from the quantitative meta-analysis , followed by an analysis of the differential contribution of study variables, using both immediate and delayed posttest administration, to the overall effect size.

Assumptions of the Statistical Model

Glass (1976) proposed a method of quantitative synthesis derived from the results of a collection of experimental/control group studies The method involved estimating the population effect size for each study and then combining the estimates across studies. The statistical analyses conducted in such studies entails the use of a t- or F-test to test the differences between groups. If the assumptions for the validity of the t-test are met, it is possible to derive the properties of the effect size exactly The assumptions can be stated in the form of equations

by the following statement: Suppose that the data arise from a series of k independent studies, where each study compares an experimental group (E) with an independent control group (C). Assume that the scores in each i^{th} study are normally distributed with mean μ_i^E and μ_i^C and common variance σ_i^2. Therefore, the effect size for the i^{th} study (δ_i) is defined as the following (Hedges, 1982, p.12).

$$\delta_i = \frac{\mu_i^E - \mu_i^C}{\sigma_i} \qquad (1)$$

The assumptions of the t-test may not always be met. However, according to Hedges (1982) the assumptions are often reasonably well satisfied in practice and theory. The proceeding description of the techniques involved in a meta-analysis will result in a reasonable approximation to reality. The ensuing results should be robust since the theory relies on the assumptions of the t-distribution (Hedges, 1982). Inevitably, the quality of the research synthesis is unlikely to be higher than the quality of the studies integrated in the analysis.

Data Collection

The data collection procedure involved acquiring all relevant empirical studies related to the effects of computer-based feedback on learning from computer-based instruction. The inclusion of all possible studies, which met the criteria, ensured that the meta-analysis comprised a representative sample of empirical studies on the topic. The search and collection of studies began in January 1991 and was terminated in December 1992.

Multiple sources of information were searched to identify all relevant research studies. First, on-line searches were conducted probing various interdisciplinary resources (see Appendix B). For example, the ERIC database was searched from 1966 to 1992 using various descriptors such as *CAI, CAI and feedback, CAL, CAL and feedback, feedback, knowledge of results, review, programmed instruction, programmed instruction and feedback*. The PsychLIT database was also searched from 1983 to 1992 using the following descriptors: *CAI, CAI and feedback, CAL, CAL and feedback, feedback, feedback in CAI, computer based instruction and feedback and learning*. The Social Citation Index and MUSE (McGill University Libraries' Online

Catalogue) were also probed using the following keywords *computer-assisted instruction (CAI), computer-assisted learning (CAL), feedback, knowledge of results, learning processes, computing research, programmed instruction, coaching* and other possible combinations

Manual searches (see Appendix C) were conducted to gather research studies that were not catalogued as part of on-line databases and to identify current studies in submission *The Educational Technology Abstracts, British Education Index, Dissertation Abstracts International, Masters Abstracts, Current Index to Journals in Education, American Education Research Association's* annual meeting program handbooks, card catalogues of Concordia university and textbooks related to the topic were searched using the following keywords: *CAI, CAI and feedback, CAL, CAL and feedback, feedback, knowledge of results, review programmed instruction, programmed instruction and feedback, feedback in CAI, computer based instruction and feedback and learning, learning processes, computing research, programmed instruction, coaching, learner model, confirmation, knowledge-based systems, artificial intelligent systems, advisement, knowledge of results, intelligent tutoring systems, and videodisc*

Research studies which were inaccessible (e.g., master's theses, dissertations, conference papers) through existing library facilities, including inter-Library Loans, were acquired by contacting the primary author for copies. The author's addresses were located in the National Faculty Directory Thirty-four (34) dissertations were identified as pertinent to the meta-analysis and the authors were contacted by mail. Under certain circumstances, a follow-up contact by telephone was necessary to remind the author to submit a copy Of the 34 authors that were contacted, only four sent copies of their students dissertations (Bumgarner, 1984; Arnett, 1985; Dempsey, 1988; Elliot, 1986)

The "ancestry approach" of identifying pertinent articles was conducted by inspecting the reference section of all the empirical studies and theoretical articles that were collected via on-line and manual searches This examination prevented the omission of relevant articles that would have otherwise been excluded from the analysis. Subsequently, all relevant articles were procured and copies were produced

Inclusion Criteria

Sixty-nine (69) studies were collected and critically evaluated for possible inclusion in the meta-analysis The inclusion criteria was derived from the meta-analytic literature (e g , Hossler & Scalese-Love, 1989), previous research findings on computer-based instruction (e g , Clark, 1983; 1984; 1985a; 1985b), previous meta-analytic reviews on feedback (e g , Bangert Drowns, Kulik, Kulik & Morgan, 1991) and other empirical features related to both the theoretical and statistical outcomes of the analysis (e.g., Bernard & Naidu, 1990) Acquired studies were evaluated systematically, and if they met the following criteria, were subsequently included in the quantitative meta-analysis

1. Study compared an experimental group receiving computer-presented feedback with a control group receiving no computer-presented feedback (at a minimum one group each)
2. Computer-presented feedback was administered following learner responses (avoided pre-search availability)
3. Study provided operational definitions of all feedback and control conditions
4. The criterion test of learning was administered either immediately following or sometime after each subject interacted with the computerized instructional lesson
5. Study provided measures of central tendency, variability, and quantitative statistical results for all experimental and control group.
6. All groups, experimental and control, consisted of equal sample sizes.
7. Studies with large sample sizes were included in the meta-analysis Larger sample size has been defined by Hedges (1982) as n^e, n^c as equal or greater to 10 subjects

The studies that were rejected due to criteria violation were subsequently included in the qualitative section of the meta-analysis The qualitative analysis included an in-depth analysis of themes based on similar methodological flaws

Coding Scheme

Previous meta-analyses related to CBI (Kulik & Kulik, 1986, Kulik, Bangert & Williams 1983) and feedback (Lysakowski & Walberg, 1982), motivational and cognitive effects of

feedback in computer-based instruction (Sales 1988). Clark's (1893; 1884, 1985b) criticism of learning from media confounding evidence in educational computing research (Clark, 1985a) and other coding schemes (e g , Hossler & Scalese-Love, 1989) obtained in the research literature were used in drafting the initial coding scheme for the extraction of study features in preparation for succeeding quantitative analyses on the effects of computer-presented feedback on learning from computer-based instruction.

The articles that met the inclusion criteria were reviewed and their study features were coded using an initial coding schema Subsequently, all unused study variables were deleted from the initial coding schema Thereafter, study characteristics were recoded and verified using the revised coding scheme (see Appendix D)

The revised coding scheme comprised of the following sections. (a) document characteristics, (b) subject characteristics, (c) instructional materials, (d) criterion test, (e) methodological features, and (f) feedback characteristics. Overall, 83 individual study features were taken into account Following the coding of study features, the studies were subdivided based on the posttest administration, immediate or delayed, and ensuing parallel quantitative analyses were conducted

Study Features

Eighty-three (83) characteristics of each study were coded twice by the author These characteristics fell into six categories document characteristics, subject characteristics, instructional materials, criterion test, methodological features and feedback characteristics. The studies were recoded by the author following the revision of the coding scheme.

The **document features** included·

- ***Study Number.*** Each study was numbered in ascending order according to the first author's surname
- ***Authors.*** The authors of each document were noted
- ***Year of Publication.*** The year in which the document became publicly available
- ***Document Source.*** Documents came from published articles, conference papers and

doctoral dissertations

The **subject characteristics** included seven features

- ***Total Sample Size.*** The total sample size for each study was noted
- ***Experimental Group Sample Size.*** The experimental group sample size was recorded.
- ***Control Group Sample Size.*** The control group sample size for each study was noted.
- ***Gender.*** The subject's gender in each study was always mixed and or specified
- ***Student Level.*** The students were usually of average level and those who were at low risk academically
- ***Academic Level.*** The studies included primary, secondary, college students and adults undergoing a teacher training program

Instructional materials included ten features.

- ***Computer-Based Instruction (CBE) Typology.*** The computerized instructional unit typology was either linear computer-assisted instruction (CAI), MAIS (Minnesota Adaptive Instructional System), computer-driven interactive video, drill & practice or branching CAI.
- ***Subject Matter Content.*** This pertained to the content of the computerized instructional unit It included medicine, genetics, relational concepts, arts/museum, multiplication tables, human eye, science, matrix algebra, research concepts, metric conversion, English composition/grammar rules, statistical concepts, TV production special effects, physics, and psychology
- ***Used an Instructional Systems Design Model.*** Did the researchers use an instructional systems design model used in the design, development and evaluation of the computerized instructional unit
- ***CBE Materials Construction.*** The computerized instructional unit was constructed by the researcher or someone other than the researcher including a teacher or

another researcher

- ***Type of Instructional Content.*** The content included concepts, rules, verbal information, inferential learning, cognitive and factual, and conceptual and factual information
- ***Duration of Treatment.*** This variable recorded the number of days the treatment lasted.
- ***Instructional Item Type.*** This variable included the type of responding the learner engaged while interacting with the instructional unit. It was either mixed types, touch screen multiple choice or completion
- ***CBE Materials are Modified Versions of Preexisting Materials.*** If some cases the instructional unit was developed from pre-existing print-based materials.
- ***Subjects Introduced to Instructional Unit.*** Were the subjects introduced to the computer system, instructional unit, sample lesson before commencing the computerized instructional unit.
- ***Format of Unit Content.*** The computerized instructional content was presented in the following formats: text, graphics, text and graphics, or video, slides and not text.
- ***Accessibility to Supplemental Instructional Materials.*** Did the students have access to supplementary instructional materials while interacting with the computerized instructional unit.

Criterion Test features included

- ***Administration of Criterion Test.*** Paper-and pencil, on-line and oral methods used to administer the posttest measuring achievement
- ***Test Material Construction.*** The posttest was constructed by the experimenter and/or researcher, domain experts, teacher or commercially available.
- ***Task Domain.*** The criterion items were targeted at the following domains. verbal information, cognitive and multiple domains.
- ***Instructional Item Type.*** The learner responded to the following type of criterion

items. open-ended question. completion type questions multiple choice. free response or mixed types of answers

- **Familiarity of Criterion Items.** The criterion items were either new items never presented in the instructional unit or items that appeared in the unit and were randomized or items similar to those presented in the unit
- **Timing of Criterion.** The posttest was administered immediately or soon after the completion of the computerized instructional unit In studies involving the delayed posttest administration, the posttest was administered a day, a week, two weeks or 14-16 weeks following the computerized instructional unit
- **Validation of Test Items Performed by.** The criterion test items were validated either by the research, instructional designers, domain experts or independent researchers.

Four **methodological** features included:

- ***Sample Selection.*** The subjects were either randomized, divided, stratified and randomized or blocked and randomized to each group in the study
- ***Participation.*** The subjects participated in the study because it was a course requirement and would affect their final grades, volunteered or a combination of both.
- ***Study Duration.*** This variable recorded the number of days the study lasted
- ***Overall Statistical Analysis.*** The overall statistical analysis of each study consisted of either an F omnibus, ANCOVA, F repeated measures, MANOVA and univariate ANOVAs.

The **feedback characteristics** included the following

- ***Number of Feedback Groups.*** The number of feedback groups used to calculate the effect size was noted.
- ***Number of Control Groups.*** The number of control groups used to calculate the effect size was noted

- ***Location of Feedback Message.*** Following a response, the instructional unit would with present the feedback message on the same screen or on a separate screen
- ***Name of Control Group.*** This included the name assigned to the control group as noted from the study (See Appendix D)
- ***Strategy Used in Control Group.*** This pertained to the strategy used in the control condition following the learner's response to some prompt while interacting with the computerized instructional unit (See Appendix D).
- ***Name of feedback Group.*** This included the name assigned to the experimental group as noted from the study (See Appendix D)
- ***General Strategy Used in feedback Group.*** The overall strategy employed by the feedback condition following the learner's correct and/or wrong responses(See Appendix D).
- ***Strategy Used in Feedback Group after Correct Answer.*** The strategy employed by the feedback condition following the learner's correct response (See Appendix D)
- ***Strategy Used in Feedback Group after First Wrong Answer.*** The strategy employed by the feedback condition following the learner's first wrong response (See Appendix D)
- ***Strategy Used in Feedback Group after Second Wrong Answer.*** The strategy employed by the feedback condition subsequent to the learner's initial wrong response (See Appendix D).

Quantitative Analyses

Studies Involving Immediate Posttest Administration

The quantitative analytic procedures involved two separate major analyses based on (a) studies involving the administration of an immediate posttest and, (b) studies involving the

administration of a delayed posttest. Parallel but separate calculations were performed throughout the quantitative component of the meta-analysis The information gathered from the methods and results sections of each study, involving immediate and delayed posttest administration, was recorded for subsequent meta-analytic procedures Such information included main effects F values related to the feedback group, t-test statistic values, total sample size, experimental and control group sample sizes, experimental and control group standard deviations, and experimental and control group means

Calculating Effect Sizes

Nineteen (19) effect sizes were extracted from fourteen (14) studies reporting F values related to a main effect for feedback and the total sample size (Anderson, Kulhavy, & Andre, 1971; Arnone, & Grabowski, 1992; Bumgarner, 1984; Chanond, 1988; Clariana, Ross, & Morrison, 1991; Gaynor, 1981; Gilman, 1969a; Gilman 1969b; Hines, & Seidman, 1988; Hodes, 1985; Schaffer, & Hannafin, 1986; Roper, 1977; Tennyson, 1981; Tennyson & Buttery, 1980). The effect size calculation involved two steps:

(a) the transformation of the feedback main effect F value into a t-test statistic by the following formula,

$$\sqrt{F} = t \qquad (2)$$

(Hunter & Schmid, 1990, p. 268), followed by

(b) the transformation of the t-test statistic to an effect size, d, using the formula described by Hunter & Schmid (1990, p. 272)

$$d = \frac{2t}{\sqrt{N}} \qquad (3)$$

the t-test statistic obtained from formula (2) was multiplied by two and the product was then divided by the square root of the total sample size

One study (Anderson, Kulhavy & Andre, 1972) reported an independent t-test statistic comparing the difference between a feedback and control group with the respective degrees of freedom. The effect size, d, was calculated using a formula described by Rosenthal (1991, p 18)

$$d = \frac{t(n_1 + n_2)}{\sqrt{df}\sqrt{n_1 n_2}} \qquad (4)$$

The numerator in formula (4) involved the multiplication of the t-test statistic by the sum of the sample size of both groups in the study The denominator involved the product of the square root of the total degrees of freedom in the study multiplied by the square root of the product each group's sample size

Fourteen (14) effect sizes were calculated from five studies that provided the experimental and control group means, standard deviations and sample sizes (Armour-Thomas, White & Boehm, 1987; Elliot, 1986, Johansen & Tennyson, 1983; Schloss, Wisniewski, & Cartwright, 1988; Tennyson, 1980) The effect size, g, involved the following calculation as described by Hedges & Olkin (1985, p. 78-79):

$$g = \frac{(\overline{Y}^E - \overline{Y}^C)}{s} = \frac{\overline{Y}^E - \overline{Y}^C}{\sqrt{\frac{(n^E - 1)(s^E) + (n^C - 1)(s^C)}{n^E + n^C - 2}}} \qquad (5)$$

This formula calculated a biased estimator of effect size, g, based on the standardized mean difference. The numerator involved the difference between the experimental group mean and the control group mean. The denominator involved the addition of the product of each group's degrees of freedom by its corresponding standard deviation divided by the total number of degrees of freedom.

Calculating the Unbiased Estimators of Effect Size

The effect sizes extracted from the five studies using the Hedges & Olkin (1985) methodology resulted in the calculation of 14 biased effect sizes, g's, which were converted into unbiased estimators of effect size, d's. The following formula (6) (Hedges & Olkin, 1985, p. 81) was employed in the transformation of biased effect size estimator (g) into unbiased effect size estimator (d)

$$d = (J - N)g \qquad (6)$$

the transformation to an unbiased effect size estimator (d) involves the multiplication of value of the biased correction factor J(m) based on the total sample size (Hedges & Olkin, 1985, p 80) by the biased effect size estimator.

Calculating the Average Mean Effect Size

The mean effect size for all the studies involving the effects of computer-presented feedback on learning as measured by the administration of an immediate posttest was calculated by summing the thirty-four (34) effect size (unbiased estimator) values and dividing the total by thirty-four.

Calculating the Weighted Mean Effect Size

The methodology described by Rosenthal (1991) was used to calculate the estimated variance of effect sizes and subsequently the weighted mean effect size The estimate variance of effect size required a three step procedure for each effect size:

(a) squaring each effect size (d^2)

(b) subtracting (d^2) from 1

(c) calculating the estimate variance of effect size, w, (Rosenthal, 1991, p.78),

$$w = \frac{N}{1 - d^2} \qquad (7)$$

(d) multiplying the value of w by the original unbiased estimator of effect size d

Lastly, the weighted mean effect size was calculated by applying the following formula (Rosenthal, 1991, p78).

$$\bar{d} = \frac{\sum w_i d_i}{\sum w_i} \qquad (8)$$

which involved the product of sum of each estimated variance of each effect size by the unbiased effect size divided by the sum of the total estimated variance

Test of Homogeneity of Effect Size

The χ^2 test of homogeneity of effect sizes was performed to test the homogeneity of effect size within the sample The formula,

$$\sum w_j (d' - \bar{d}')^2 \qquad (9)$$

(Rosenthal, 1991, p.79), involved summing the product of the estimated variance of each effect size, w', by the squared difference of unbiased effect size and weighted mean difference of effect size The product was then multiplied by the estimated variance of each estimated effect size The calculated value χ^2 (33, N=22) = 558.60 was compared with the hypothetical χ^2 value with k -1 degrees of freedom The k represented the number of effect sizes minus 1 The calculated value χ^2 = 558.60, $p < .05$ exceeded the χ^2 critical value of 43.77 and therefore the thirty-four (34) effect sizes were considered significantly heterogeneous

ANOVA Procedure of Study Features

Frequency distributions and measures of central tendency were performed on the 83 study variables which were initially coded using the coding scheme. For further statistical analyses, twenty-two (22) of eighty-three study features were selected, based on the comparable frequencies in each category The harmonic subcommand of the ANOVA procedure for unequal group sizes of the Statistical Package for the Social Sciences (SPSSx, ver 4.1) software was used to calculate one-way ANOVAs for each of the following study features document source, academic level, computer-based education typology, subject matter content, use of an instructional design model, computer-based education material construction, type of instructional content, instructional item type, whether CBE materials were modified version of preexsiting materials, format of unit content, accessibility to supplemental instructional materials, administration of criterion test, test material construction, task domain, instructional item type of criterion posttest, familiarity of criterion items, timing of criterion, validation of test items performed by, sample selection, participation, strategy used by feedback group.

Multiple Regression for Study Features Contributing to Effect Size

The ANOVAs procedure on twenty-two (22) study features resulted in nine (9) significant F omnibus values The actual probabilities (related to α) corresponding to these significant F values were recorded for inclusion in a multiple regression analysis The search for the three study features with the lowest probability values is related to the inclusion of a single variable for each 10 subjects in an experiment (Tabachnick & Fidell, 1989) In this case, the total number of subjects or effect sizes was thirty-four (n=34) and thus only 3 study features would be incorporated into the multiple regression analysis. Three study features with the lowest probability values, *computer-based education typology, format of unit content, and accessibility to supplemental materials*, were introduced into a stepwise multiple regression analysis

Studies Involving Delayed Posttest Administration

Calculating Effect Sizes

Five (5) effect sizes were extracted form three (3) studies (Chanond, 1988, Clariana, Ross & Morrison, 1991; Gaynor, 1981) reporting F values related to a main effect for feedback The effect size calculation involved the transformation of the feedback main effect into a t-test statistic by employing equation (2) followed by the conversion of the t-test statistic into an effect size, d, via equation (3)

One study (Anderson, Kulhavy & Andre, 1971) reported an independent t-test statistic comparing the difference between a feedback and control group with the respective degrees of freedom An effect size was calculated using a formula (4) described by Rosenthal (1991, p 18)

Three (3) effect sizes were calculated from one study (Armour-Thomas, White & Boehm, 1987) that provided the experimental and control group means, standard deviations and sample sizes The effect size, g, was calculated using formula (5)

Calculating the Unbiased Estimators of Effect Size

The effect sizes extracted from one study using the Hedges & Olkin (1985) methodology resulted in the calculation of a biased effect sizes, g, which were converted into an unbiased estimator of effect size, d Formula (6) (see Hedges & Olkin, 1985, p 81) was employed in the

transformation of the biased effect size estimator (g) into an unbiased effect size estimator (d) The transformation to an unbiased effect size estimator (d) involved the multiplication of value of the biased correction factor J(m) based on the total sample size (Hedges & Olkin, 1985, p 80) by the biased effect size estimator

Calculating the Average Mean Effect Size

The mean effect size for all the studies involving the effects of computer-presented feedback on learning as measured by the administration of a delayed posttest was calculated by summing the nine (9) effect size (unbiased estimator) values and dividing the total by nine

Calculating the Weighted Mean Effect Size

The methodology described by Rosenthal (1991) was used to calculate the estimated variance of effect sizes and subsequently the weighted mean effect size The estimate variance of effect size required a three step procedure for each effect size.

(a) squaring each effect size (d^2)

(b) subtracting (d^2) from 1

(c) calculating the estimate variance of effect size, w, (Rosenthal, 1991, p.78);

$$w = \frac{N}{1 - d^2}$$

(d) multiplying the value of w by the original unbiased estimator of effect size d

Lastly, the weighted mean effect size was calculated by applying formula (8) which involved the product of sum of each estimated variance of each effect size by the unbiased effect size divided by the sum of the total estimated variance

Test of Homogeneity of Effect Size

The χ^2 test of homogeneity of effect sizes was performed to test the homogeneity of effect size within the sample. Formula (9) involved summating the product of the estimated variance of each effect size, w, by the squared difference of unbiased effect size and weighted mean difference of effect size The product was then multiplied by the estimated variance of each estimated effect size The calculated value χ^2 (8, N=9) = 25.39 was compared with the

hypothetical χ^2 value with k -1 degrees of freedom The k represented number of effect sizes minus 1 The calculated value χ = 25.39, $p <$ 05 exceeded the critical χ value of 15 51 and therefore the nine (9) effect sizes were signific intly heterogeneous

ANOVA Procedure of Study Features

The frequencies and means of seventeen (17) of eighty-three (83) study variables were calculated. The study features included: document source, academic level, computer-based education typology, subject matter content, use of an instructional design model, type of instructional content, instructional item type, whether CBE materials were modified version of preexisting materials, whether subjects were introduced to the instructional unit, format of the unit content, accessibility to supplemental instructional materials, task domain, instructional item type of criterion posttest, timing of criterion, sample selection, participation, strategy used by feedback group. The calculation of one-way ANOVAs was inconceivable since the frequency distributions revealed study features with category sample sizes of one (1)

RESULTS

Figure 1 summarizes the results of the data collection procedure The on-line and manual searches resulted in the collection of fifty-nine studies (N=59) Thirty-seven studies (63%) were rejected from the quantitative meta-analysis due to failure to meet the inclusion criteria (see Appendix E) These studies were discussed in the qualitative analysis according to similar methodological flaws Twenty-two (37%) studies met the inclusion criteria and were subsequently included in the quantitative analysis (see Appendix F) Of the 22 studies that met the inclusion criteria, 17 involved immediate posttest administration, 4 included immediate and delayed posttest administration and 1 study involved delayed posttest administration only

Quantitative Results

Studies Involving Immediate Posttest Administration

The effect size values for all the studies involving immediate posttest administration are displayed in Table 1 The following number of effect sizes were extracted from the twenty-two studies One effect size was extracted from Anderson, Kulhavy and Andre (1971), Anderson, Kulhavy and Andre (1972), Arnone and Grabowski (1992), Bumgarner (1984), Chanond (1988), Clariana, Ross and Morrison (1991), Gilman (1969a), Gilman (1969b) Hines and Seidman (1988), Hodes (1985), Roper (1977), Schaffer and Hannafin (1986), Tennyson (1981), Tennyson and Buttrey (1980), two from Elliot (1986), three from Armour-Thomas, White and Boehm (1987), Gaynor (1991), Johansen and Tennyson (1983), Tennyson (1981) and four from Schloss, Wisniewski and Cartwright (1988)

Thirty-four (34) effect sizes were calculated from 22 studies including 2 studies reporting 2 experiments (Anderson, Kulhavy & Andre, 1971; Tennyson, 1981). The unweigthed mean effect size for studies involving immediate posttest administration was 0.73 with a standard deviation of 0 57 This effect size calculation was based on a total sample size of 2201. The overall weighted mean effect size was 80 ($p < 05$) (see Appendix G). The magnitude and direction of the effect size indicate that achievement outcomes were greater for the feedback group than the no-feedback (control) group On average, computer-presented feedback made a

Figure 1 *Scheme outlining the number of studies and effect sizes extracted from the data collection procedure*

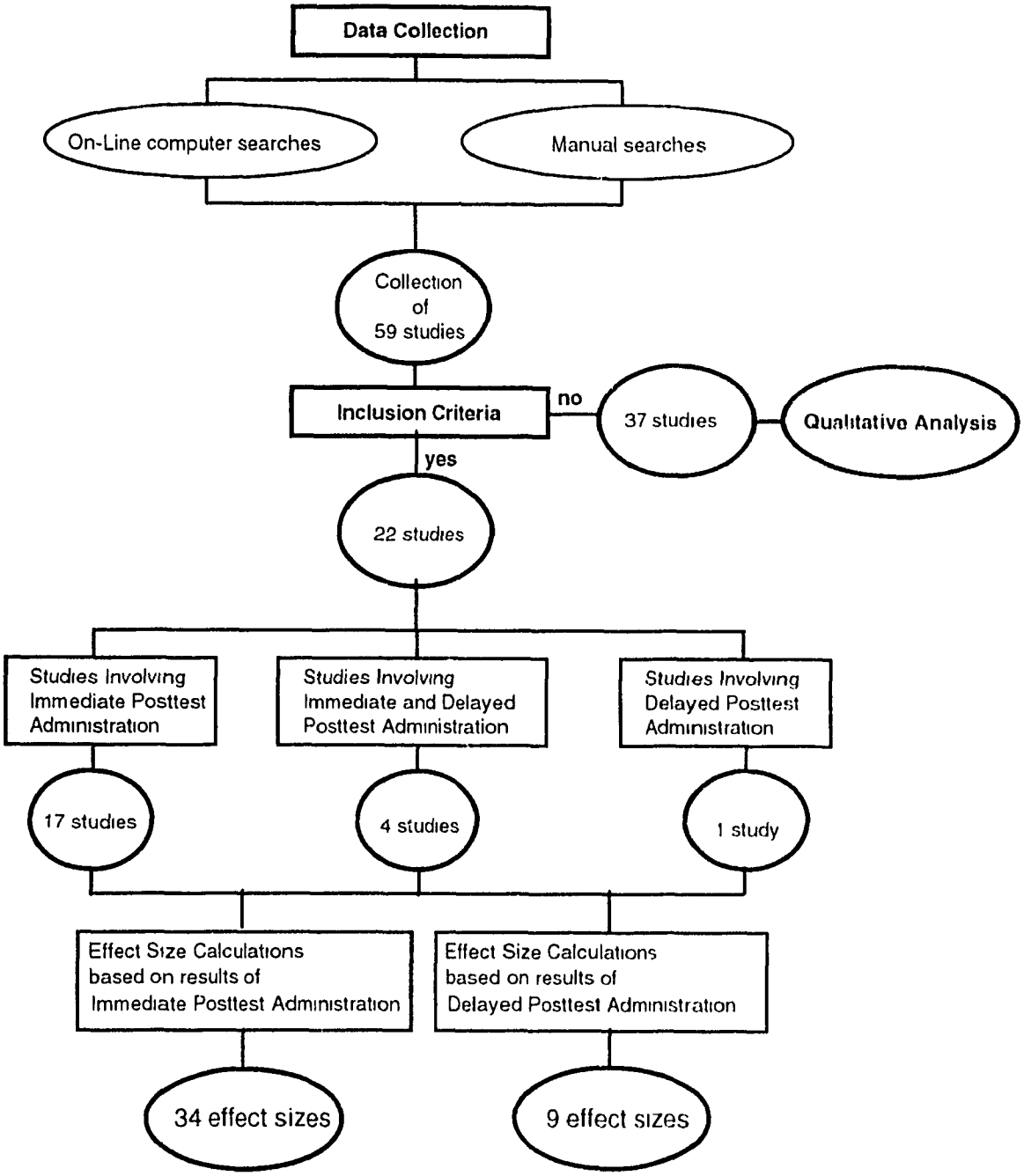


Table 1

Effect Sizes Extracted from Studies Involving Immediate Posttest Administration

Study #	Authors	N	n^e	n^c	d
1	Anderson et al., 1971 [1]	168			0.03
3	Anderson et al , 1972	48	24	24	0.43
4	Armour-Thomas et al , 1987	46	23	23	0 46
4	Armour-Thomas et al , 1987	44	21	23	0.54
4	Armour-Thomas et al , 1987	45	22	23	0.45
5	Arnone et al , 1992	52	25	27	0.18
6	Bumgarner 1984	41			0.12
7	Chanond 1988	120			0.77
8	Clariana et al., 1991	100			0.80
9	Elliot 1986	42	20	22	0.42
9	Elliot 1986	42	20	22	0 55
10	Gaynor 1981	92			0.22
10	Gaynor 1981	92			0.20
10	Gaynor 1981	92			0.15
11	Gilman 1969a	75			0.46
12	Gilman 1969b	75			0.38
13	Hines et al , 1988	221			0.07
14	Hodes 1985	41	21	20	0.14
15	Johansen et al , 1983	32	16	16	1.48
15	Johansen et al , 1983	32	16	16	1.94
15	Johansen et al , 1983	32	16	16	2.12
16	Roper 1977	36			0.92
17	Schaffer et al , 1986	98			0.99
18	Schloss et al , 1988	25	7	18	0.40
18	Schloss et al., 1988	25	7	18	0 31
18	Schloss et al , 1988	25	7	18	0.57
18	Schloss et al , 1988	25	7	18	1 37
19	Tennyson 1980	46	23	23	1.81
19	Tennyson 1980	46	23	23	0 93
20	Tennyson 1981 [1]	63			1.63
21	Tennyson 1981 [2]	47			0.90
21	Tennyson 1981 [2]	47			1.00
21	Tennyson 1981 [2]	47			1.36
22	Tennyson et al , 1980	139			0.69
		2201	**298**	**350**	**Mean E.S. 0.73**
					S.D. 0.57
					Weighted E.S. 0.80

1	1st study of experiment	N	total sample size	d, E.S.	effect size
2	2nd study of experiment	n^e	experimental group sample size	S.D.	standard deviation
N	total sample size	n^c	control group sample size		

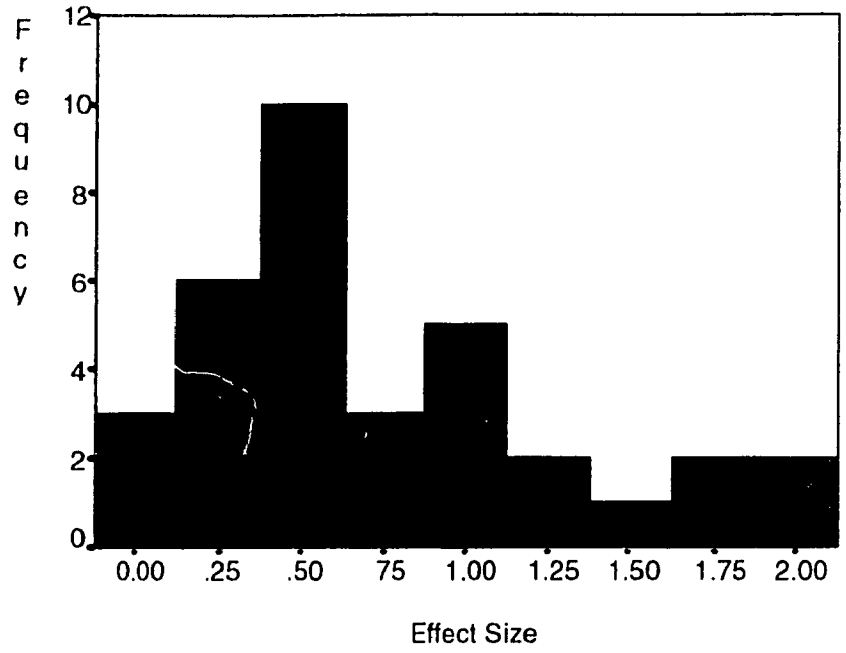
larger contribution to achievement, raising scores by four-fifths of a standard deviation (ES= 80) This is equivalent to raising achievement scores from the 50th percentile to the 79th percentile Likewise, learners receiving computer-presented feedback were found to perform 80 standard deviations above (or, on average, better than 79%) learners receiving no computer-presented feedback.

Figure 2 shows the distribution of effect sizes (n=34) extracted from studies involving immediate posttest administration. Effect sizes, all positive, ranged from a very low 0 03 standard deviations to a very high 2.12 standard deviations The large range of effect size values indicated the potential benefits of computer-presented feedback on achievement As such, one-way ANOVAs were calculated between the categories pertaining to each study feature

The effect sizes, in descending order of magnitude, and the CBI typology are displayed in Table 2. The largest effect sizes, with the exception of one study (Schloss *et al*, 1988), were all extracted from studies using MAIS. As indicated in Table 2, MAIS resulted in achievement increases ranging from 1 00 to 2.12 standard deviation units Effect sizes ranging from 0 99 to 0.69 were attributed to studies employing a multitude of CBI typologies, such as computer-driven interactive video, MAIS, branching and linear CAI Effect sizes between 0 20 and 0 60 were all related to studies involving the use of linear CAI as the CBI typology The low end of the effect sizes (from 0.18 to 0 03) involved the use of different CBI typologies such as computer driven interactive video, linear and branching CAI

The study number, author's names, total sample size, control and feedback sample sizes, names of control and feedback groups, and the effect sizes of studies involving immediate and delayed posttest administration are displayed in Table 3 Studies that involved immediate posttest administration investigated the effects of computer-presented feedback by comparing one or two control groups with as many as one to seven feedback groups The names of both control and feedback groups reflect the diversity of empirical questions in studying the effect of different feedback messages on learning from CBI For example, there are studies investigating the effects of manipulating the content of feedback messages, format of feedback message,

Figure 2 *Histogram of Effect Sizes (n=34) Involving Studies with Immediate Posttest Administration*



learner/program control and advisement, immediacy of feedback message, combination of feedback strategies empirical questions on learning from computer-based instruction.

Analyses on Study Features

The results of the one-way ANOVAs between the categories of each study feature are displayed in Table 4. The study variable, study feature, number of effect sizes, mean effect size for each category and the F omnibus values , if appropriate, for each category within a study feature is displayed.

Document Features

The years of publication for studies involving immediate posttest administration ranged from 1969 to 1992

Document Source. The majority of the studies included in the meta-analysis came from published journal articles (n=26), followed by conference papers (n=5) and dissertations (n=3). The mean effect sizes for published journal articles, conference papers and dissertations are respectively, 0.83, 0 46 and 0 36. A one-way ANOVA showed no significant differences between

Table 2

Effects Sizes in Descending Order of Magnitude and the Corresponding CBI Typologies in Studies Involving Immediate Posttest Administration

Study #	Authors	d	CBI Typology
15	Johansen et al., 1983	2 12	MAIS
15	Johansen et al., 1983	1.94	MAIS
19	Tennyson 1980	1.81	MAIS
20	Tennyson 1981[1]	1.63	MAIS
15	Johansen et al., 1983	1.48	MAIS
18	Schloss et al., 1988	1 37	Linear CAI
21	Tennyson 1981[2]	1.36	MAIS
21	Tennyson 1981[2]	1.00	MAIS
17	Schaffer et al., 1986	0.99	CDIV
19	Tennyson 1980	0.93	MAIS
16	Roper 1977	0.92	Linear CAI
21	Tennyson 1981[2]	0.90	MAIS
8	Clariana et al., 1991	0.80	Branching CAI
7	Chanond 1988	0.77	Linear CAI
22	Tennyson et al., 1980	0.69	MAIS
18	Schloss et al., 1988	0.57	Linear CAI
9	Elliot 1986	0.55	Linear CAI
4	Armour-Thomas et al., 1987	0.54	Linear CAI
4	Armour-Thomas et al., 1987	0.46	Linear CAI
11	Gilman 1969a	0.46	Linear CAI
4	Armour-Thomas et al , 1987	0 45	Linear CAI
3	Anderson et al , 1972	0.43	Linear CAI
9	Elliot 1986	0.42	Linear CAI
18	Schloss et al., 1988	0.40	Linear CAI
12	Gilman 1969b	0 38	Linear CAI
18	Schloss et al., 1988	0.31	Linear CAI
10	Gaynor 1981	0 22	Linear CAI
10	Gaynor 1981	0 20	Linear CAI
5	Arnone et al., 1992	0.18	CDIV
10	Gaynor 1981	0 15	Linear CAI
14	Hodes 1985	0.14	Branching CAI
6	Bumgarner 1984	0.12	Branching CAI
13	Hines et al., 1988	0 07	Branching CAI
1	Anderson et al , 1971[1]	0.03	Linear CAI

1 **1st study of experiment**
2 **2nd study of experiment**
d **effect size**
CDIV **computer-driven interactive video**

Table 3

Authors, Names of Control and Feedback Groups and Effect Sizes from Studies Involving both Immediate and Delayed Posttest Administrations

Study #	Authors	N	n^e	n^c	Control Group	Feedback Group	d Immediate	d Delayed
1	Anderson et al 1971 [1]	168			0% KCR	100% KCR	0 03	
						KCR-R		
						10% KCR-R		
						KCR-W		
						Time Out		
						Correct		
						Voluntary		
2	Anderson et al , 1971 [2]	50	24	26	0% KCR	100% KCR		0.62
3	Anderson et al., 1972	48	24	24	0% Standard	100% Standard	0 43	
4	Armour-Thomas et al., 1987	46	23	23	Control	Textual KR	0.46	
		44	21	23	Control	Symbolic KR	0.54	
		45	22	23	Control	Pictorial KR	0.45	
		46	23	23	Control	Textual KR		0.30
		44	21	23	Control	Symbolic KR		0.42
		45	22	23	Control	Pictorial KR		0 28
5	Arnone et al., 1992	52	25	27	Learner Control	Learner Control with Advisement	0.18	
6	Bumgarner 1984	41			NFB + NSR	KOR +NSR	0 12	
						KOR +CP +NSR		
7	Chanond 1988	120			Control	Feedback	0 77	
		103			Control	Feedback		0.26
8	Clariana et al , 1991	100			Questions without feedback	KCR	0 80	
					No Questions	AUC		
						Delayed Feedback		
		100			Questions without feedback	KCR		0 60
					No Questions	AUC		
						Delayed Feedback		
9	Elliot 1986	42	20	22	Text + Q	Text + Q+ F	0.42	
		42	20	22	Text + Q	Text + Q+ F	0.55	

table continues

Study #	Authors	N	n^e	n^c	Control Group	Feedback Group	d Immediate	d Delayed
10	Gaynor 1981	92			Control	Immediate	0.22	0 18
						30 Second Feedback		
						EOS		
		92			Control	Immediate	0.20	0.22
						30 Second Feedback		
						EOS		
		92			Control	Immediate	0.15	0 15
						30 Second Feedback		
						EOS		
11	Gilman 1969a	75			Control	Correct or Wrong KOR	0.46	
						KCR		
						Response Contingent		
						Combination		
12	Gilman 1969b	75			Control	KOR	0 38	
						KCR		
						Response Contingent		
						Combination		
13	Hines et al , 1988	221			Linear	External Control Immediate Feedback	0.07	
						External Control Delayed Feedback		
						Internal Control Immediate Feedback		
						Internal Control Delayed Feedback		
14	Hodes 1985	41	21	20	Noncorrective Feedback	Corrective Feedback	0.14	
15	Johansen et al , 1983	32	16	16	Learner Control	Learner Control and Advisement	1 48	
		32	16	16	Learner Control	Learner Control and Advisement	1 94	
		32	16	16	Learner Control	Learner Control and Advisement	2 12	

table continues

Study #	Authors	N	n^e	n^c	Control Group	Feedback Group	d Immediate	d Delayed
16	Roper 1977	36			No Feedback	KR	0 92	
						KR + KCR		
17	Schaffer et al., 1986	98			Video	Video + Question + KR	0.99	
					Video + Question	Fully Interactive		
18	Schloss et al , 1988	25	7	18	Closed Loop No Feedback	Closed Loop and Feedback	0.40	
		25	7	18	Forced Loop No Feedback	Forced Loop and Feedback	0 31	
		25	7	18	Closed Loop No Feedback	Closed Loop and Feedback	0.57	
		25	7	18	Forced Loop No Feedback	Forced Loop and Feedback	1.37	
19	Tennyson 1980	46	23	23	Learner Control	Learner Adaptive Control	1.81	
		46	23	23	Learner Control	Learner Adaptive Control	0.93	
20	Tennyson 1981[1]	63			Learner Control	Learner Adaptice Control	1.63	
						Adaptive Control		
21	Tennyson 1981[2]	47			Learner Control	Learner-Adaptive Control	0.90	
						Adaptive Control		
		47			Learner Control	Learner-Adaptive Control	1 00	
						Adaptive Control		
		47			Learner Control	Learner-Adaptive Control	1.36	
						Adaptive Control		
22	Tennyson et al., 1980	139			Learner Control No Advisement	Learner Control With Advisement	0.69	
					Adaptive Control No Advisement	Adaptive Control With Advisement		
						Weighted Mean Effect Size	**0.80**	**0.35**

1 1st study of experiment

2 2nd study of experiment

Table 4

Effect Size as a Function of Study Variable in Studies with Immediate Posttest Administration

Study Variable	# of Effect Sizes	Mean E.S.	F value
Document Source			
Published journal article	26	0.83	
Conference paper	5	0.46	
Dissertation	3	0 36	**F(2,33)=1.73**
Academic Level			
Primary School	5	0.35	
Secondary School	13	1.08	
College	16	0.58	**F(2,33)=5.30***
CBE typology			
Linear CAI	18	0.49	
Minnesota Adaptive Instructional System	10	1.39	
Computer-driven Interactive Video	2	0.59	
Branching CAI	4	0.28	**F(3,33)=14.34****
Subject Matter Content			
Medicine	2	0 55	
Science	9	0.82	
Concepts	7	1.01	
Arts/TV Production	2	0.59	
Mathematics/ Statistics	9	0.56	
Psychology/Special Education	5	0.67	**F(5,33)=0.62**
Used an Instructional Systems Design Model			
Yes	13	1 12	
No	21	0.50	**F(1,33)=13.03****
Course (CBE) Materials Construction			
Someone other than researcher	7	0.36	
Experimenter/Researcher developed	11	1 27	**F(1,17)=14.20****
Type of Instructional Content			
Concepts	8	0 69	
Concepts & Factual	5	0.81	
Rules	7	1.28	
Verbal Information	2	0.42	
Inferential Learning	3	0.59	
Cognitive and Factual	4	0.66	**F(5,28)=1.46**
Instructional Item Type			
Mixed Types	1	0 28	
Touch Screen	1	0.18	
Multiple Choice	12	0.64	
Completion	3	1 85	**N/A**

table continues

Study Variable	# of Effect Sizes	Mean E. S.	F value
CBE materials were modified versions of preexisting materials			
Yes	14	0.89	
No	10	0 63	**F(1,33)=1.76**
Subjects were introduced to instructional unit			
Yes	24	0.84	
No	10	0.50	**F(1,33)=2.72**
Format of Unit Content			
Graphics	3	0.48	
Text	3	1.85	
Multiple formats	2	0.23	**F(2,7)=45.00****
Accessibility to supplemental instructional materials			
Yes	10	1.24	
No	24	0.53	**F(1,33)=16.47****
Administration Criterion Test			
Paper-and-pencil	18	0.43	
On-line	6	1.65	
Orally	1	0.18	**N/A**
Test Material Construction (Control for Test-Author Bias)			
Experimenter/Researcher Developed	2	0.95	
Developed by others (experts, researchers)	7	0.31	
Teacher Developed	2	0.52	**F(2,10)=1.86**
Task Domain			
Verbal Information	1	0.77	
Multiple Domains	3	0.59	
Cognitive	3	0.19	**N/A**
Instructional Item Type			
Mixed types of answers	2	0.36	
Open-ended questions	1	0.18	
Completion	4	1.42	
Multiple choice	10	0.86	
Free Response	3	0.19	**N/A**
Familiarity of Criterion Items			
New Items	11	0.93	
Criterion Items Appeared in Instruction	10	0.64	**F(1,20)=2.20**
Timing of Criterion			
Immediately after lesson	33	0.74	
10 Minutes after lesson	1	0.80	**N/A**

table continues

Study Variable	# of Effect Sizes	Mean E.S.	F value
Validation of Test Items Performed by			
Researcher	2	1.37	
Other researcher/teacher/expert	3	0.52	**F(1,4)=3.53**
Sample Selection			
Stratified and then Randomized	8	0.38	
Random	23	0.84	
Blocked and Randomized	1	0.99	
Divided	1	0.14	**N/A**
Participation			
Course Requirement (would affect final grades)	14	1.05	
Volunteers (would not affect final grades)	3	0.58	
Combination (1 & 2)	1	0 43	**N/A**
Strategy used in feedback group			
Present feedback after each item	6	0.33	
Subject given control. advise provided guidance and encouraged curiosity	1	0.18	
Received feedback based on (a)correctness of answer, and (b) confidence level	1	0.77	
Identified wrong answer as "wrong"	1	0.14	
Presented KOR (correct and wrong), presented correctly punctuated sentence and identified the rule	3	1.85	
Received feedback concerning accuracy of answer	1	0.99	
Advised on the number of items for mastery and advise on what concept to see next	3	1 46	
Continuously selected examples, and sequenced examples according to the subject's performance	3	1.09	**N/A**

the mean effect sizes of the three categories (F[2,33]=1.73, $p>.05$).

Subject characteristics

The sample size of studies involving immediate posttest administration ranged from 25 to 336 subjects The experimental group sample sizes ranged from 7 to 25 while control group sample sizes ranged from 16 to 27 subjects Both genders were represented in the twenty-two studies.

Student Level. A complete description of student level could not be obtained due to poor description of subjects in individual studies. However, two effect sizes were calculated from

studies involving average level students and one involving academically low-risk students

Academic Level. The studies included primary (n=5), secondary (n=13), college students (n=16). The college student category comprised of fifteen effect sizes involving college students and one effect size involving adults enrolled in a teacher training course A significant difference was obtained from the one-way ANOVA calculated between the mean effect sizes for each category, $F(2,33)=5.50$, $p< 05$ The highest mean effect size was obtained from the secondary school subjects (1 08), followed by college (0 58) and primary students (0.35).

Instructional Materials

Computer-Based Education (CBE) Typology. A one-way ANOVA conducted between linear computer-assisted instruction (n=18), MAIS (n=10), computer-driven interactive video (n=2) and non-branching CAI (including 3 drill and practice and 1 branching CAI) revealed a significant difference between computer-based education typologies, $F(3,33)=14.34$, $p<.01$ The mean effect sizes decrease with diminishing adaptiveness with computer-based education typologies, MAIS, computer-driven interactive video, linear and branching CAI.

Subject Matter Content. The original content categories (medicine, genetics, relational concepts, arts/museum, multiplication tables, human eye, science, matrix algebra, research concepts, metric conversion, English composition/grammar rules, statistical concepts, TV production special effects, physics, and psychology) were recoded into six new more general categories of subject matter content The recoded categories included, medicine (medicine and human eye), science (genetics, science and physics), concepts (relational concepts, research concepts, English composition rules), arts/museum (art museum, television production special effects), mathematics/statistics (multiplication table, matrix algebra, metric conversion, statistics), psychology/special education (special education and psychology) No significant differences were found between the mean effect sizes of these categories ($F[5,33]=0.62$, $p>.05$).

Used an Instructional Systems Design Model. The use of an instructional systems design model in the development of the computerized lesson makes a difference in terms of posttest achievement scores as indicated by a significant difference between mean effect sizes

(F[1,33]=13.03, p<.01)

CBE Materials Construction. The mean effect size for computerized instructional units constructed by the researcher was greater than for units constructed by someone other than the researcher (F[1,17]=14.20, p< 01)

Type of Instructional Content. Content such as concepts (n=8), rules (n=7), verbal information (n=2) , inferential learning (n=3), cognitive and factual (n=4), and conceptual and factual information (n=5) did not differ significantly (F[5,28]=1 46, p>.05)

Duration of Treatment. The duration of treatments included 1 day (35%), 6 days (9%), 72 days (9%) Since information concerning the duration of the treatment was missing 47% percent of the time, no statistical comparison was conducted.

Instructional Item Type. The highest mean effect size was obtained from completion type instructional items (1.85) followed by multiple choice (0.64), mixed type (0 28) and touch screen (0.18). An ANOVA was not calculated because categories with the mixed type and touch screen item types consisted of one effect size each.

CBE Materials are Modified Versions of Preexisting Materials. The mean effect size for instructional units developed from preexisting print-based materials was slightly larger but not significant than when the materials were developed for study purposes (F[1,33]=1.76)

Subjects Introduced to Instructional Unit. The introduction of subjects to the instructional unit prior to treatment exposure was slightly higher but not significant for students who were not given a brief introduction to the computerized environment, experimental conditions and sample screens (F[1,33]=2 72, p> 05)

Format of Unit Content. A significant difference (F[2,7]=45 00, p<.01) was obtained when the mean effect sizes related to the format of each unit content were compared. Content in the form of text, produced the largest effect size, 1 85 standard deviations. Graphics produced nearly half a standard deviation followed by multiple formats (which included 1 effect size involving text and graphics and another with video slides and no text)

Accessibility to Supplemental Instructional Materials. Student's access to

supplementary instructional materials while interacting with the computerized instructional unit produced a significant difference in their average effect size (F[1,33]=16 47 p< 01) compared with the absence of supplemental materials. The supplementary aids consisted of print-based materials available to students while they interacted with the instructional unit. In some cases, the supplemental material provided the learner with rules, examples of rule use, and brief explanations

Criterion Test

Administration of Criterion Test. On-line posttest administration resulted in a slightly larger mean effect size than paper-and-pencil and oral posttest administration An ANOVA was not conducted since the category representing the oral criterion test adminstration comprised one effect size

Test Material Construction. Control for test-author bias did not produce significant mean differences (F[2,10]=1.86, p>.05) The mean effect was higher for posttests constructed by the researcher

Task Domain. A test of effect size mean differences between categories in the verbal information, cognitive and multiple domains was not possible since verbal information contributed only one effect size The category with the highest mean effect size consisted of the verbal domain followed by multiple and cognitive domains

Instructional Item Type. Completion type criterion test items produced the highest mean effect size, 1 42 standard deviations This was followed by multiple choice (SD=0.86), mixed type (SD=0.36), free response (SD=0 19) and open-ended questions (SD=0 18)

Familiarity of Criterion Items. There were no significant differences between the presentation of new criterion items and the appearance of items already presented in the instructional unit (F[1,20]=2.20, p> 05) The category of items already presented in the instructional unit were based on the recoding of 3 effect sizes based on the presentation of the exact items; 1 effect size of items that appeared in the instructional unit but were randomized in the criterion test; 4 effect sizes on items that were similar to the instructional items; and 2 effect

sizes with items similar to instructional unit but reworded

Timing of Criterion. There was no difference between the mean effect size based on the posttest administration. Thirty-three effect sizes (97%) were calculated from studies involving immediate posttest administration while 1 effect size (3%) was calculated from a study where the posttest was administered 10 minutes after the subjects completed the instructional unit

Validation of Test Items Performed by the Researcher or Others. The validation of the criterion items, either by the researcher or someone other than researcher, did not produce a significant difference between mean effect size ($F[1,4]=3.53$, $p>.05$)

Methodological Features

Sample Selection. Larger mean effect sizes were calculated from studies involving the blocking and randomizing of subjects (0.99), followed by randomization (0.84), stratified and randomization (0.38) and divided (0.14). The calculation of an effect size was not possible since one effect size was obtained from studies involving the blocking and randomization and division of subjects across experimental conditions

Participation. The largest mean effect size was obtained from studies where the subjects participation counted for marks and affected their final grades (SD=1 05) The participation of volunteers and other subjects, where study involvement constituted a course requirement, produced an effect of about half a standard deviation unit.

Study Duration. Each study lasted anywhere from 1 day (6%), 4 days (3%), 1 week (12%), one month (3%), two months (3%) and six weeks (9%) In twenty-two cases (65%) the study duration was not reported.

Feedback Characteristics

Number of Feedback Groups. Nearly half (47%) of all effect sizes were calculated from studies using one feedback group. The other half of effect sizes were calculated from studies ranging from two to seven feedback groups in the study

Number of Control Groups. The majority (85%) of all effect size calculation were based on studies involving one control group. The remaining (15%), used two control groups

Location of Feedback Message. Following a response, the instructional unit would present the feedback message on the same screen (3%) or on a separate screen (3%) Thirty-two (92%) of the effect sizes came from studies that omitted any mention regarding the location of the feedback message following learner response

General Strategy Used in feedback Group. The highest mean effect size was obtained from studies where the overall strategy employed by the feedback condition involved either an adaptive instructional approach, elaborate explicatory feedback message following the learner response to an instructional item. The lowest mean effect sizes were achieved from studies where the feedback condition's strategy involved the presentation of simple feedback following an instructional item, confirmation feedback and encouraged curiosity

Table 5 displays the frequencies and percentages of names and the strategies used in control and feedback groups in studies involving immediate posttest administration. The name "control" was the most commonly used for the control group (28%), followed by 0% standard group (21%) The names of control groups are, in some cases, the opposite of their feedback counterparts. For example, the control condition 0% KCR has an equivalent feedback condition named 100% KCR Furthermore, the name of the other control groups, as indicated by their name, reflect the absence of some variable that was included in the feedback condition For example, the "learner control without advisement" has an equivalent feedback group named "learner control with advisement"

The most common strategy used in control groups involved the lack of a feedback message after each item (45%) The second most common strategy (37%) involved a learner control where the learner had complete control over the instructional interaction (sequencing, pacing, stopping, remediation, exiting) The other strategies included a variation of the two most common strategies They included the presentation of a new item after each response and the presentation of other media without the feedback message.

A definitive synthesis of feedback groups was impeded by the immense variation in feedback group names, operational definitions, immediacy of feedback message presentation,

Table 5

Frequency and Percentages of Names and Strategies Used in Feedback and Control Groups in Studies Involving Immediate Posttest Administration.

	Frequency	Percentage
Name of Control Groups		
0% KCR	1	2%
0% standard	1	2%
Control	9	21%
Learner Control	12	28%
NFB (no feedback)	2	5%
Questions without feedback	1	2%
No questions	1	2%
Linear	1	2%
Non-corrective feedback	1	2%
Video	1	2%
CL/NF (closed loop, no feedback)	4	10%
FL/NF (forced loop, no feedback)	4	10%
Learner Control Without Advisement	1	2%
Adaptive Control Without Feedback	1	2%
Text + Q (questions)	2	5%
Video + Q (question)	1	2%
Strategy Used in Control Groups		
No feedback presented after each item	17	45%
Subject given complete control over sequencing, pacing, stopping, remediation, and exiting (Learner Control)	14	37%
No feedback presented following each response and presented next problem	1	3%
Given new frame of instruction after each answer and certitude level	1	3%
No feedback provided after each response and proceed to next problem after correct or wrong answer	1	3%
Received informational feedback after entire presentation (atypical feedback condition)	2	6%
Presentation of a linear videotape	1	1%
Presentation of linear videotape plus questions	1	1%

table continues

	Frequency	Percentage
Name of Feedback Groups		
100% KCR	1	1%
KCR-R	1	1%
10% KCR-R	1	1%
KCR-W	1	1%
Time-Out	1	1%
Correct	1	1%
Voluntary	1	1%
100% Standard	1	1%
Textual	1	1%
Symbolic	1	1%
Pictorial	1	1%
Learner Control with Advisement	2	3%
KOR (Knowledge of Results)	2	3%
KOR+CP (Knowledge of Results plus Corrective Procedure)	1	1%
Feedback	1	1%
KCR (Knowledge of Results)	3	4%
AUC (Answer Until Correct)	1	1%
Delayed feedback	2	3%
Immediate feedback	3	4%
30 second feedback	3	4%
EOS (End of Session)	6	12%
"Wrong" and "Correct" KCR	1	1%
Response Contingent	4	5%
Combination (KCR + "Wrong" and "Correct" KCR + Response Contingent)	1	1%
External Control Immediate Feedback	1	1%
External Control Delayed Feedback	2	3%
Internal Control Immediate Feedback	1	1%
Internal Control Delayed Feedback	1	1%
Corrective Feedback	1	1%
Learner Control with Advisement	3	4%
KR	1	1%
KR + KCR	1	1%
Video + questions + feedback	1	1%
Fully interactive	1	1%
CL/F (Closed loop, feedback)	4	5%
FL/F (Forced loop, feedback)	4	5%
Learner Adaptive Control	8	10%
Adaptive Control	1	1%
Learner Partial Control	3	4%
Adaptive Control with Advisement	1	1%
Text + Q + F (question + feedback)	2	3%
Combination (KOR + KCR + Response Contingent)	1	1%

table continues

	Frequency	Percentage
General Strategy used in Feedback Groups		
Presented feedback after each item	8	20%
No feedback after responding	1	3%
Subject given total control and advisement provide guidance and encouraged curiosity	1	3%
Received different feedback message based on (a)correctness of answer and, (b)confidence level	1	3%
Identifies wrong answer as wrong	1	3%
Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule	3	8%
Correct answer stated in context of question	1	3%
Feedback received concerning accuracy of answer	1	3%
Feedback for correct and wrong answers, video branching until correct answer attained	1	3%
Advise on the number of item needed for mastery, advise on what concept to see next	6	15%
Continuously selected examples, and sequenced examples according to subject's performance	4	10%
Assessed subject's progress for selection of examples	3	8%
Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)	1	3%
Received feedback 30 seconds after responding to an item	3	8%
Received feedback after completion of lesson	5	13%
Strategy used in Feedback Groups after Correct Answer		
Presented feedback after correct answers only	1	4%
Presented feedback after a percentage of correct answers only	1	4%
No feedback presented	1	4%
Presented feedback after each item	1	4%
"CORRECT" displayed following response and proceeded to next problem	1	4%
"CORRECT" displayed	5	19%
Statement of praise followed by the answer	2	8%
"Answer ____ is correct"	1	4%
Received the word "RIGHT" after each response	2	8%
Received feedback concerning the response's correctness	2	8%
"CORRECT" and feedback appropriate to response	1	4%
Presented next screen of information	8	31%

table continues

	Frequency	Percentage
Strategy used in Feedback Groups after First Wrong Answer		
No feedback presented after each wrong answer	1	4%
time delay before presentation of feedback	1	4%
Looped to same frame and try again	1	4%
"WRONG" displayed following response and proceeded to next problem	1	4%
"WRONG" then try again	1	4%
"WRONG" with correct answer and forced to type letter of correct answer to continue	1	4%
"NO, TRY AGAIN" displayed on the bottom of the screen	1	4%
"WRONG" after each response	3	12%
Showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text	2	8%
Received feedback concerning incorrectness of answer	2	8%
"ANSWER _ _ is correct"	1	4%
"ANSWER __ is correct" and explanation	1	4%
"WRONG" and feedback, "CORRECT ____" and explanation	1	4%
Ability to see particular screen	4	15%
Presented screen with relevant information	4	15%
Presented feedback after wrong answers only	1	4%
Strategy used in Feedback Groups after Second Wrong Answer		
Presented feedback	1	9%
Informed of correct response, required subject to type correct answer, presented next problem	1	9%
"WRONG" and type letter corresponding to correct answer	1	9%
Indicate correct answer and move to next screen	4	36%
Move to next screen of information	4	36%

format of feedback message, content of feedback message and other experimental variables. There were a total of forty-two (42) feedback groups included in the studies involving immediate posttest administration (see Table 5) The most common feedback groups were the End of Session (EOS) (12%) and Forced Loop feedback (10%) EOS feedback conditions presented the message following an entire section of the instructional unit whereas, learner adaptive control condition provided the learner with complete freedom regarding the instructional path. The application of multiple names for feedback groups involving the presentation of similar feedback messages is a common finding There was no significant difference in the feedback message of these groups. Other studies investigated the effects of immediate and delayed feedback on achievement posttest scores. For example, Gaynor (1981) studied the effects of immediate, 30

second and delayed feedback on achievement Furthermore, a greater complication to the immediacy variable is the addition of a second experimental variable For example, Hine's et al (1988) study involved external control immediate delayed, external control delayed feedback, internal control immediate delayed, and internal control delayed feedback Another factor involved studying the effects of feedback presentations on learning For example, one report studied the difference between textual, symbolic and pictorial feedback messages (Armour-Thomas *et al.*, 1987).

The general strategy used in feedback groups is displayed in Table 5 Most studies involved a general strategy for correcting errors. The most common strategy was the presentation of a feedback message after each item (20%) This was followed by the strategies used by MAIS including advising the learner on the number of items needed for mastery and the next concept (15%), and the instructional sequencing based on the continuous monitoring of the student's performance (10%). The remaining strategies differed in the timing of feedback message presentation and content of feedback message

Some studies involved precise strategies for dealing with correct answers The most common strategy after a correct answer was to present the next item of information (31%) This was followed by the presentation of a simple confirmation feedback statement (displayed by the word "CORRECT") The other strategies following a correct response included, the absence of a feedback message, statement of praise, statement concerning response's correctness, presentation of the feedback message, presentation of a feedback message following a percentage of correct responses

The feedback groups contained strategies able to convey the correctness of response to the learner and comprised additional strategies to handle subsequent errors The three most common strategies used by feedback groups after the first wrong answer consisted of the ability to see a particular screen (15%), present the screen with the relevant information (15%), and the presentation of the word "WRONG" after each response The range of strategies included the absence of feedback, time delay in presenting the feedback message and presentation of the

correct answer The most common strategy after erring twice on the same item included the presentation of the next screen of information (36%) or an indication of the correct answer followed by the presentation of the next screen (36%)

Multiple Regression

A stepwise multiple regression approach was conducted to determine the strength of relationship among the three study features and their outcomes after accounting for correlations among study features The three features with the lowest actual probabilities (related to α) from the independent one-way analyses of variance procedures were entered into a multiple regression analysis The variables were *computer-based education typology, format of unit content, and accessibility to supplemental materials* Each variable was entered in a stepwise fashion The order of entry in the analysis was based on the descending bivariate correlation value between each variable and effect sizes The variables most strongly related to effect size (*accessibility to supplemental materials* and *format of unit content*) together accounted for 96% of the variance in the effect (R= 98)

Studies Involving Delayed Posttest Administration

The nine effect sizes extracted from five studies with the corresponding total sample, experimental and control group sizes are presented in Table 6. One effect size was extracted from each study except for the studies conducted by Armour-Thomas *et al* (1987) and Gaynor's (1981) which contributed three effect sizes

Figure 3 shows the distribution of effect sizes (n=9) extracted from studies involving delayed posttest administration Effect sizes, all positive, ranged from 0.15 standard deviations to 0.62 standard deviations. The unweigthed mean effect size was 0.34 with a standard deviation of 0 17 The effect size calculation was based on a total of 665 subjects from five studies The overall weighted mean effects size was 0.35 ($p<.05$) (see Appendix H) The small effect size and positive direction indicate that achievement outcomes were greater for feedback than no-feedback (control) group. On average, computer-presented feedback seems to make a slightly larger contribution to achievement, raising scores by three tenths of a standard deviation

Table 6

Effect Sizes Extracted from Studies Involving Delayed Posttest Administration

Study #	Authors	N	n^e	n^c		d
2	Anderson et al., 1971 [2]	50	24	26		0.62
4	Armour-Thomas et al., 1987	46	23	23		0.30
4	Armour-Thomas et al., 1987	44	21	23		0.42
4	Armour-Thomas et al., 1987	45	22	23		0.28
7	Chanond 1988	103				0.26
8	Clariana et al., 1991	100				0.60
10	Gaynor 1981	92				0.18
10	Gaynor 1981	92				0.22
10	Gaynor 1981	92				0.15
					Mean E.S.	**0.34**
		664	**90**	**95**	**S.D.**	**0.17**
					Weighted E.S.	**0.35**

2 **study 2 of experiment**

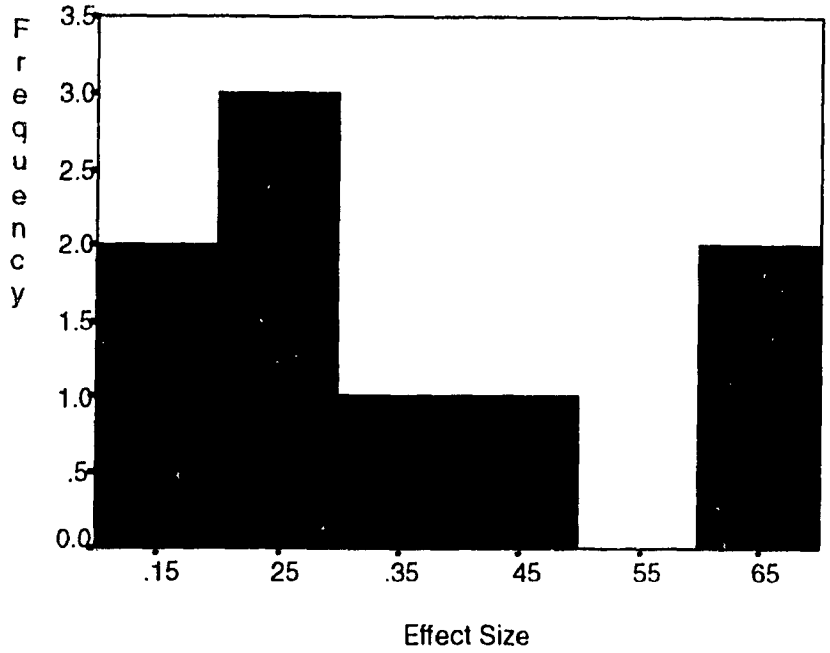
N **total sample size**

n^e **experimental groups sample size**

n^c **control group sample size**

d **effect size**

Figure 3. *Histogram of Effect Sizes (n=9) Involving Studies with Delayed Posttest Administration.*



(ES= 35) This is equivalent to raising achievement scores from the 50th percentile to the 64th percentile Likewise, learners receiving computer-presented feedback were found to perform 35 standard deviations above (or, on the average, better than 64%) learners receiving no computer-presented feedback.

The effect sizes, in descending order of magnitude, and the CBI typology are displayed in Table 7. All effect sizes with the exception of one study (Clariana *et al.*, 1991) were extracted from studies involving the use of linear computer-assisted program. The exception, which resulted in second highest effect size (0.60) was from a study involving a drill and practice CBI unit.

Table 7

Effects Sizes in Descending Order of Magnitude and the Corresponding CBI Typologies in Studies Involving Delayed Posttest Administration

Study #	Authors	d	CBI Typology
2	Anderson et al., 1971 [2]	0.62	Linear CAI
8	Clariana et al., 1991	0.60	Branching CAI
4	Armour-Thomas et al., 1987	0.42	Linear CAI
4	Armour-Thomas et al., 1987	0.30	Linear CAI
4	Armour-Thomas et al., 1987	0 28	Linear CAI
7	Chanond 1988	0.26	Linear CAI
10	Gaynor 1981	0.22	Linear CAI
10	Gaynor 1981	0.18	Linear CAI
10	Gaynor 1981	0.15	Linear CAI

2 study 2 of experiment
d effect size

Studies that involved delayed posttest administration investigated the effects of computer-presented feedback by comparing one control group with one feedback group (see Table 3). Clariana *et al* (1991) represented the exception by comparing two control group with three feedback groups The names of both control and feedback groups reflect the diversity of

interest in studying the effect of delaying feedback messages on learning from CBI For example, there are studies investigating the effects of no feedback versus feedback after each item; the format of feedback message (textual, symbolic and pictorial), and the immediacy of feedback message (knowledge of results, answer until correct and delayed feedback)

Analyses on Study Variables

The study variable, number of effect sizes, and the mean effect size for each category within a study variable in studies involving delayed posttest administration is displayed in Table 8 The maximum number of effect sizes per study variable was nine. Therefore, each study variable and its categories will be analyzed according to the mean effect size

A comparison of means indicated that published journal articles produced a larger mean effect size (0 35) than conference papers (0 32) The mean effect size involving studies with secondary school students produced a greater mean effect size (0.60) as compared to the mean effect sizes in studies involving primary school (0 33) and college students (0 29) An effect size derived from a study involving a drill and practice typology obtained a larger mean effect(0 60) than eight effect sizes extracted from studies using linear CAI (0.30). The use of an instructional systems design model is related to a larger mean effect size (0.62) than eight effect sizes extracted from studies that did not employ the use of an ISD model (0 30) in the development of the instructional unit. Differences in mean effect sizes were also encountered in relation to the type of instructional content; inferential learning produced the greatest mean effect size (0 60) followed by concepts (0.33) and verbal information (0.26). Mixed instructional item types produced the largest mean effect size (0 62) as compared to multiple choice (0.43) The mean effect size from studies involving the construction of CBE materials from preexisting materials did produce a slightly larger mean effect size (0 43) than when the materials were designed specifically for the purposes of the study (0.31). The mean effect size extracted for studies involving the introduction of the instructional unit prior to the investigation is smaller (0 18) than when subjects simply asked to engage in the control experimental conditions without any explanation as to the types of instructional activities he/she was about to experience (0 43) The

Table 8

Effect Size as a Function of Study Variable in Studies with Delayed Posttest Administration

Study Variable	# of Effect Sizes	Mean E.S.
Document Source		
Published journal article	5	0.35
Conference paper	4	0.32
Academic Level		
Primary School	3	0.33
Secondary School	1	0.60
College	5	0.29
CBE typology		
Linear CAI	8	0.30
Drill & Practice	1	0.60
Subject Matter Content		
Medicine	1	0.62
Relational Concepts	3	0.33
Human Eye	1	0.26
Science	1	0.60
Matrix Algebra	3	0.18
Used an Instructional Systems Design Model		
Yes	1	0.62
No	8	0.30
Type of Instructional Content		
Concepts	3	0.33
Verbal Information	1	0.26
Inferential Learning	1	0.60
Instructional Item Type		
Mixed Types	1	0.62
Multiple Choice	2	0.43
CBE materials were modified versions of preexisting materials		
Yes	2	0.43
No	7	0.31
Subjects were introduced to instructional unit		
Yes	3	0.18
No	6	0.41
Format of Unit Content		
Text & Graphics	1	0.62
Graphics	3	0.33

table continues

Study Variable	# of Effect Sizes	Mean E.S.
Accessibility to supplemental instructional materials		
Yes	1	0.60
No	8	0 30
Task Domain		
Verbal Information	1	0.26
Multiple Domains	1	0 60
Cognitive	3	0.18
Instructional Item Type		
Mixed types of answers	1	0.62
Multiple choice	2	0.43
Free Response	3	0.18
Timing of Criterion		
1 Week after Lesson	1	0.2
2 weeks after Lesson	4	0.29
14-16 Weeks after Lesson	1	0 62
Missing Information	3	0 33
Sample Selection		
Stratified and then Randomized	4	0.29
Random	5	0.37
Participation		
Course Requirement (would affect final grades)	4	0.29
Volunteers (would not affect final grades)	2	0.43
Strategy used in feedback group		
Present feedback after each item	4	0.29
Received feedback based on (a)correctness of answer, and (b) confidence level	1	0.26

format on the unit content, in the form of text and graphics produced a larger mean effect size (0.62) than when the unit was presented in the form of graphics (0.33). Student's accessibility to supplemental instructional materials resulted in a mean effect size that was twice the size (0.60) than when the students lacked the ability to consult supplemental materials as they interacted with the instructional unit (0.30). The use of multiple domains in the criterion test produced a higher mean effect size (0.60) than when test items pertained to verbal information (0 26) and cognitive (0 18) domains. Furthermore, mixed instructional items produced a higher mean effect size (0.62) than multiple choice (0.43) and free response (0 18) open-ended responses.

Interestingly, there was an inverse association between mean effect size and timing of delayed posttest administration The mean effect size was highest from a study where the posttest was administered fourteen to sixteen weeks following the instructional unit (0.62) followed by a two week (0.29) and finally a one week delay (0.20) between completion of the instructional unit and posttest administration However, three effect sizes calculated from studies missing timing of criterion resulted in a mean effect size of 0.33 standard deviations. The assignment of students to control and experimental conditions resulted in a mean effect size favoring the randomization (0.37) versus stratification followed by randomization of subjects to control and experimental groups (0.29). The mean effect size for studies involving volunteers (0.43), whose final grades would not be affected by their performance on the instructional unit, outperformed the students whose participation was a course requirement (0.29). The results of the strategies used by feedback groups resulted in two strategies: present feedback after each item (0.29) edged feedback presentation based on level of response correctness and learner level of confidence when responding to an instructional item (0.26)

Table 9 displays the frequencies and percentages of names and the strategies used in control and feedback groups in studies involving delayed posttest administration. "Control" was the name most used (70%) for a control group The strategies used in the control groups are similar since the majority (80%) did not present any feedback message following the students' response The other twenty percent (20%) present a new frame of instruction after each response and certitude level. In fact, these two strategies are basically identical and are characterized by the presentation of new instructional material following a learner's response without a feedback message.

The feedback groups differ in respect to the immediacy of feedback message presentation, format of feedback message and content of feedback message The most common used feedback groups involved an immediate feedback condition (20%) and a thirty second (delayed) feedback condition (20%). Feedback messages differing in format included textual (7%), symbolic (7%) and pictorial (7%). The other differences were related to the content

Table 9

Frequency and Percentages of Location of Feedback Message, and Strategies Used in Feedback and Control Groups in Studies Involving Delayed Posttest Administration.

	Frequency	Percentage
Name of Control Groups		
0% KCR	1	10%
Control	7	70%
Questions without feedback	1	10%
No questions	1	10%
Strategy Used in Control Groups		
No feedback presented after each item	4	80%
Given new frame of instruction after each answer and certitude level	1	20%
Name of Feedback Groups		
100% KCR	1	7%
Textual	1	7%
Symbolic	1	7%
Pictorial	1	7%
Feedback	1	7%
KCR (Knowledge of Results)	1	7%
AUC (Answer Until Correct)	1	7%
Delayed feedback	1	7%
Immediate feedback	3	20%
30 second feedback	3	20%
EOS (End of Session)	1	7%
General Strategy used in Feedback Groups		
Presented feedback after each item	4	40%
Received different feedback message based on (a)correctness of answer and, (b)confidence level	1	10%
Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)	1	10%
Received feedback 30 seconds after responding to an item	3	30%
Received feedback after completion of lesson	1	10%
Strategy used in Feedback Groups after Correct Answer		
"CORRECT" displayed	2	100%
Strategy used in Feedback Groups after First Wrong Answer		
"WRONG" with correct answer and forced to type letter of correct answer to continue	1	50%
"NO, TRY AGAIN" displayed on the bottom of the screen	1	50%
Strategy used in Feedback Groups after Second Wrong Answer		
"WRONG" and type letter corresponding to correct answer	1	100%

of the feedback message which included knowledge of results (7%), knowledge of correct response (7%), answer until correct (7%) and end of session feedback (7%)

The basic difference between the general strategies used by the feedback groups was in the timing of feedback message presentation. Forty percent (40%) of the time feedback was presented after each item followed by the presentation of a feedback message thirty seconds after responding to an item (30%) Two similar strategies included the presentation of feedback following the completion of the lesson (10%) and the presentation of feedback after completion of the instructional unit along with the display of each question with the corresponding correct answer (10%). Only once (10%) did the feedback message differ depending on the correctness of the answer and the student's level of confidence concerning the certainty in his/her answer

A small number of the feedback groups possessed strategies to communicate to the learner the correctness of his/her answer and other included additional strategies capable of handling subsequent errors. The only general strategy, resulting from two instances, used in feedback groups was to display the word "CORRECT" following the student's response The two most common strategies used in feedback groups after the first wrong answer were either to present "WRONG, TRY AGAIN" on the bottom of the screen or display the word "WRONG" along with the correct answer and forcing the student to type in the correct answer to continue These strategies are "canned" feedback messages with limit algorithmic functionality regarding their adaptiveness related to the identification of the error

Qualitative Results

The following were rejected from the quantitative meta-analysis because of inclusion criteria violations (see Table 10) The studies were sub-divided and results were discussed according to methodological flaws

Table 10

Studies Eliminated from the Meta-Analysis (n=37)

Source	Methodological Flaws							
Author	Lack of a Control Group	Small Sample Size	Non-CBI Control Group	Feedback Conditions Selected by Subjects	Incomparable Treatment Groups	Inappropriate Dependent Measure	Feedback Presented to Control Group	Problems with Data & Statistical Analyses
Arnett, P. P. (1985)	•			•				
Carrier, C. A., & Sales, G. C. (1987)				•				
Collins, M., Carnine, D., & Gersten, R. (1987)	•							
Corbett, A. T., & Anderson, J. R. (1989)	•							•
Corbett, A. T., & Anderson, J. R. (1990)								•
Corbett, A. T., Anderson, J. R., & Patterson, E. G. (1990)	•			•				
Dalton, D. W., & Hannafin, M. (1985)								•
Dempsey, J. V. (1988)	•							
Dempsey, J. V., & Driscoll, M. P. (1989)			•					
Gilman, D. A. (1967)			•					
Grabinger, R. S., & Pollock, J. (1989)	•				•			
Hansen, J. B. (1974)						•		

table continues

Author	Lack of Control Group	Small Sample Size	Non-CBI Control Group	Feedback Conditions Selected by Subjects	Incomparable Treatment Groups	Inappropriate Dependent Measure	Feedback Presented to Control Group	Problems with Data & Statistical Analyses
Hedberg, J. G., & McNamara, S.E (1985)	•							
Kim, J-Y., L., & Phillips, T.L. (1991)	•							
Lajoie, S., & Lesgold, A. (1989)			•			•		
Lee, W-T., & Zalatimo, S. (1990)					•			
Levert, S. G. (1987)	•	•						
Merrill, J. (1985)	•							
Merrill, J. (1987)	•							
Merrill, M.D. (1965)						•		•
Mevarech, Z. R., & Ben-Artzi, S. (1987)			•					
Munro, A., Fehling, M R., & Towne, D. M. (1985)	•					•		
Ormrod, J. E. (1986)							•	
Phillips, J. R., & Berkhout, (1978)			•					

table continues

Author	Lack of Control Group	Small Sample Size	Non-CBI Control Group	Feedback Conditions Selected by Subjects	Incomparable Treatment Groups	Inappropriate Dependent Measure	Feedback Presented to Control Group	Problems with Data & Statistical Analyses
Rankin, R. J., & Trepper, T (1978)	•							
Santiago, R. S , & Okey, J. R. (1992)	•							
Schimmel, B. J. (1986)				•				
Schimmel, B. J. (1988)				•				
Schooler, L. J., & Anderson, J. R. (1990)	•							
Siegel, M. A., & Misselt, A. L. (1984)	•							
Steinberg, E.R., Baskin, A.B., & Hoffer, E. (1986)						•		
Tait, K., Hartley, J. R., & Anderson, R. C. (1973)								•
Undheim, J. O. (1987)			•					•
Waldrop, P. B., Justen, J. E., & Adams, T. M. (1986)	•							
White, A. W., Troutman, A. P., & Stone, D. E. (1991)	•							
Wigton, R. S., & Patil, K. D., & Hoellerich, V. L. (1986)							•	•
Yerushalmy, M. (1991)		•						

Studies with One Methodological Flaw

The number of studies with one methodological flaw are included in Table 11

Table 11

The Number of Studies and the Nature of the Methodological Flaw

Number of Studies	Methodological Flaws
11	Lack of a control group
4	Non-CBI control groups
3	Feedback conditions selected by subjects
3	Problems with data and statistical analyses
2	Inappropriate dependent measures
1	Small sample size
1	Incomparable treatment groups
1	Feedback presented to control group

Studies Lacking a Control Group (n=11)

Eleven studies (23%) were rejected from the quantitative analyses due to a lack of a control group (see Table 10). These studies compared the difference between feedback groups on some measure of achievement The names of feedback groups and operational definitions indicated that none of these studies included a no feedback (control) group. All studies compared different feedback groups, based on their operational definitions Their exclusion from the quantitative analysis was inevitable due to the lack of a no feedback control group. The lack of systematic use of operational definitions among feedback groups in the area of CBI impeded the use of meta-analytic procedures to extract effect sizes from studies lacking a control group Nevertheless, other striking themes emerged from these studies.

First, the results of these studies seem to indicate that the feedback group provided an elaborate explanation (e.g , elaborate corrective feedback , informational feedback, complex corrective feedback, adaptive advisement, adaptive feedback with training and extended feedback) other than just a message of confirmation. In addition, these groups were statistically significant in comparison to the simple confirmation type feedback group on an posttest

administered following the computerized instructional unit Studies comparing feedback groups that differed slightly in their approach to correcting errors produced non-significant results For example, White, Troutman and Stone (1991) conducted *post hoc* analyses on achievement scores and found no significant differences between KOR (knowledge of results) KCR (Knowledge of correct results) and KER (knowledge of elaborate results).

Other studies (e g , Hedberg & McNamara, 1985; Santiago & Okey, 1992) resulted in interactional effects between feedback conditions and instructional variables (e.g., field independence and dependence, locus of control orientation). For example, field dependent subjects made fewer errors when provided with an explanation of their errors and strategies for correcting them, while, field independent subjects committed fewer errors when given an indication that an error was made.

Merrill (1985; 1987) empirically tested high and low cognitive level questions with corrective feedback and attribute isolation feedback (AIF). The potential benefits of attribute isolation feedback (informed student of correct or incorrectness of their answer and isolates the attributes of the concepts being studied to improve further response) was not attainable because the computer-based science lesson was designed to provide AIF after two incorrect responses

Study with a Small Sample Size (n=1)

One study (Yerushalmy, 1991) investigated the effects of a variety of computerized feedback presentations on student's performance in carrying out algebraic transformations and the student's performance in debugging their own working processes. Twenty-five students were divided into four groups, each working on a different version of the same experimental software. The four groups consisted of: (1) graphical feedback (n=4) (2) judgmental feedback (n=7) , (3) symbolic manipulator aid (n=6), and (4) control group (n=3). As shown, the extraction of an effect size was impossible due to the small sample size in each of the four groups. Hedges (1982) has indicated that a group must contain at least ten subjects in order to be included in a meta-analysis Moreover, the external validity of such a study is hampered due to small sample size

Studies with a Non-CBI Control Group (n=4)

Four studies compared a computer-based instructional feedback group with a non CBI control group The control groups consisted of a no-treatment comparison classroom (Dempsey & Driscoll, 1989), linear programmed text (Gilman, 1967), traditional-lecture-discussion method (Mevarech & Ben-Artzi, 1987) and technical manual (Phillips & Berkhout, 1978)

Studies where Subjects Selected the Feedback Message (n=3)

These studies investigated student differences in selecting feedback containing different amounts of information while working alone or in groups The frequencies of feedback messages showed pairs selecting more elaborate feedback (Carrier & Sales, 1987), while individuals selected more knowledge of results (Carrier & Sales, 1987). The correctness of response does not seem to influence the type of feedback selected by the learner Schimmel's (1986, 1988) experiments showed that students preferred correct response feedback after correct and wrong responses and more explanatory feedback after incorrect responses

Studies with Incomparable Treatment Groups (n=1)

Lee and Zalatimo (1990) conducted a study to investigate the effects of feedback immediacy in teaching analogies A comparison was made between the computer-assisted instruction group, programmed instruction text group and the no-feedback control group's posttest scores on solving 5 types of analogies.

Studies with Inappropriate Dependent Measures (n=2)

The dependent measures in both studies are in accordance with the research inquiry of performance and justly used valid measures; state anxiety measures (Hansen, 1974), number of steps per problem, identification per problem and the time spent on each problem (Steinberg, Baskin & Hoffer, 1986). The initial potential for inclusion was based on the computer-presented feedback but the research objective involved performance not achievement

Studies where Feedback was Presented to the Control Group (n=1)

Ormrod (1986) investigated the effects of both feedback and practice on the learning of word spelling. In the no feedback (control) group, any spelling that was outside the tolerance level

led to the display of a negative feedback message to the learner

Studies with Problems with Data and Statistical Analyses (n=3)

Problems encountered consisted of *t-test* calculations on data from three independent groups and posttest means without central tendency values (Corbett & Anderson, 1990), Dalton and Hannafin's (1985) summary table displayed groups means and sample sizes minus the respective standard deviations and the calculation of a t-test statistic following the collapse of two feedback groups with a control group (Tait, Hartley & Anderson, 1973).

Studies with Multiple Methodological Flaws

Eleven studies were found to contain multiple methodological flaws in their attempt to investigate the effects of feedback on learning from CBI (see Table 12).

Table 12

The Number of Studies and the Nature of the Methodological Flaws

Number of Studies	Methodological Flaws
2	Lack of control group and feedback condition selected by subject
2	Lack of control group and inappropriate dependent measures
1	Lack of control group and problems with data and statistical analyses
1	Lack of control group and incomparable treatment groups
1	Lack of control group and small sample sizes
1	Non-CBI control group and inappropriate dependent measures
1	Non-CBI control group and problems with data and statistical analyses
1	Inappropriate dependent measures and problems with data and statistical analyses
1	Feedback presented to control group and problems with data and statistical analyses

Lack of control group and feedback condition selected by subject (n=2)

Arnett (1985) conducted an investigation on the effects of control over feedback strategies (learner versus program control) on learning from a computer-based lesson on classifying instructional objectives according to Gagne's Scheme The feedback strategies were examined using a computer-feedback group and a treatment group (learner controlled feedback) that allowed students to select the feedback conditions. Similarly, Corbett and Anderson's (1990) experiment with the Lisp Intelligent Tutoring System provided assistance to students working on

Lisp coding exercises employed a student-controlled feedback tutor making it possible for students to select immediate feedback concerning their program code

Lack of control group and inappropriate dependent measures (n=2)

Munro, Fehling and Towne (1985) used two approaches to provide informative feedback in dynamic skill training in a computer-based training experiment. The effects of instructional feedback treatment (continuous monitoring with the capability of immediate intervention) and less-intrusive conditions where students determined when and whether they would view the error messages were evaluated by the number of errors committed by each group Likewise, Schooler and Anderson (1990) assessed the effects of feedback (immediate and delayed) and focus (directive and non directive) within the context of the GRAPES Lisp tutor using the number of errors, time to complete problems and the percentage of self-corrected errors as the dependent measures.

Lack of control group and problems with data and statistical analyses (n=1)

Corbett and Anderson's (1989) initial study on the Lisp tutor compared the standard immediate feedback tutor and the flag tutor Additionally, an effect size was not calculated since the percentage of correct response for each group was insufficient to calculate an effect size

Lack of control group and incomparable treatment groups (n=1)

Grabinger and Pollock (1989) developed an expert system as a feedback stimulus component of an instructional unit that taught the production of graphics instructional material. Students were assigned to either the internal (provided by the expert system) or external (provided by an instructor) feedback condition.

Lack of control group and small sample sizes (n=1)

A study on the effects of imitating-modeling feedback in spelling instruction using CAI with learning disabled children compared a total of twenty-seven students assigned to three feedback groups (oral feedback, written feedback and oral/written feedback) on their spelling performance.

Non-CBI control group and inappropriate dependent measures (n=1)

Lajoie and Lesgold's (1989) experiment with SHERLOCK, a computer-based coached practice environment was compared with print-based materials with the dependent measure consisting of the number of problems solved.

Non-CBI control group and problems with data and statistical analyses (n=1)

Undheim (1987) compared the effect of different feedback approaches in the spelling performance of dyslexic children. The computer presented word-for-word feedback while students in the other group received text feedback provided by a human tutor. In addition, the results section are in prose format ("results showed small and insignificant differences in the acquisition rate depending on method of feedback", p 437)

Inappropriate dependent measures and problems with data and statistical analyses (n=1)

A test of the hypothesis that learning and retention of a hierarchical task are facilitated by mastering each successive part of material was tested in a computer-based teaching system involving complex imaginary science concepts (Merrill, 1965) The results are unintelligible because the dependent measures used number of errors and time to complete the task, as well as lacked statistical information concerning the achievement of the conditions

Feedback presented to control group and problems with data and statistical analyses (n=1)

Wigton, Kashinath, Patil and Hoellerich (1986) investigated the effects of feedback presented to medical residents concerning the weighing of their medical diagnosis via computer system that generated simulated cases The control group received outcome feedback in the form of the probability associated with the weighted diagnosis provided by each subject. Furthermore, the authors conducted a bivariate correlation between the group's accuracy scores.

DISCUSSION

Feedback has to be regarded as one of the most critical components of computer-based instruction Its objective, in instruction, should be to provide the student with the appropriate response contingent information to allow the learner to rectify his/her misconception regarding the response he/she has provided Thus, the system must be programmed to provide feedback that identifies the underlying misconception of the student and hence deliver the appropriate feedback message. The feedback message should be designed so as to stimulate cognitive processes and strategies so the learner may utilize the information provided to correct any misconception he/she possesses. Hence, feedback should aim at correcting any variations (e g , errors) the student possesses regarding the correctness of his/her answer and allow him/her to proceed through the instructional activities in a manner that is perceived as moving in a desirable productive direction.

Crucial Role of Feedback in Computerized Instruction

The importance of feedback as a critical component of instruction and learning can be explicated by the magnitude and direction of the mean effect size involving studies with immediate posttest administration (see Table 1, Figure 2). The unweighted mean effect size of .80 indicated that achievement outcomes were greater for the feedback group than the control group. This large effect size (Cohen, 1969) was interpreted as computer-presented feedback raising achievement scores by four fifths of a standard deviation or equivalently learners in the computer-presented feedback group performed better than 79% of the learners in the control group.

The present study constitutes the meta-analysis synthesizing feedback-related issues with the largest mean effect size in studies involving immediate posttest administration It was higher than meta-analyses involving the instructional effect of feedback in test-like situations which resulted in an average effect size of 0.26 (Bangert-Drowns Kulik, Kulik & Morgan, 1991), the timing of feedback in verbal learning (ES=0 34) (Kulik & Kulik, 1988) but smaller than Lysakowski and Walberg's (1982) quantitative synthesis of the instructional effects of cues,

participation and corrective feedback (ES= 97) However, the meta-analysis conducted by (Schimmel, 1983) on the effects of feedback on learners in computerized and programmed instruction also resulted in a small mean effect size of 0 47 This asserts the importance of feedback, especially in learning from computer-based education.

The delayed posttest administration results indicated a decrease in long-term retention (ES=0 35) as measured by achievement posttest scores and in comparison to the 0.80 weighted mean effect size of the immediate posttest administration The smaller mean effect size is important regarding the importance of feedback in instruction and can be explained by comparing the strategies used in the control and feedback groups in studies involving both immediate and delayed posttest administration

A comparison of the general strategies used in the control and feedback groups of studies involving both immediate and delayed posttest administration provides partial explanatory evidence as to the difference between weighted mean effect sizes (0.80 versus 0.35) Studies involving immediate posttest administration compared control groups that basically presented the next screen of instruction following the learner's response without the presentation of a feedback message In contrast, feedback groups generally included adaptive instructional approaches of continuous monitoring of student performance followed by the provision of advise concerning number of examples, and sequence of instruction as well as elaborative feedback messages. Conversely, studies involving delayed posttest administration incorporated control groups that omitted the presentation of a feedback message and proceeded to the next instructional sequence while the feedback groups presented feedback that differed in immediacy of delivery, format and content

A discussion of the general strategies following correct, first wrong and second wrong responses demonstrated further evidence concerning the differences in overall mean effect sizes. The studies involving immediate posttest administration included specific general strategies including the incorporation of immediate (after each item and advisement) and delayed feedback at the conclusion of the lesson where studies involving delayed posttest administration included

the presentation of feedback messages that differed in immediacy of delivery format and content

The majority of studies involving posttest administration comprised three specific strategies that dealt with the first error The feedback condition either presented or allowed the learner the ability to view the screen with relevant information pertaining to his/her incorrectness, encouraged the learner to try again or showed a remedial sequence, and some gave the learner the correct answer and then proceeded with the lesson The feedback groups of studies involving delayed posttest administration provided the correct answer and forced student to type in the correct answer to continue, or encouraged the student to try again

All the studies, involving immediate and delayed posttest administration, incorporated the same strategies in dealing with a learner's subsequent error to the same instructional item Both indicated the correct answer and proceeded to the next screen or required the learner to type the correct answer so proceed to the next instructional sequence. This approach is inefficient in terms to rectifying a learner's error since it assumes that the learner will comprehend the reason he/she erred when the correct answer is provided This represents a fundamental flaw arising from the computerized instruction's failure to understand the nature of the learner error and thus providing the learner with an inappropriate feedback message

The difference between overall weighted mean effect sizes comparing strategies used in control and feedback groups in studies involving both immediate and delayed posttest administration reflect the amount of cognitive engagement as its immediate and its effects on long-term retention The studies involved in immediate posttest administration tended to use strategies that were more effective in engaging the learner in cognitive activities such as advisement and review of material that facilitated material learning as measured by achievement tests. Explanatory difficulties regarding strategies used in studies involving delayed posttests stem from the application of feedback messages that differ in immediacy, format and content

The magnitude of effect size based on CBE typology used in individual studies is pertinent and requires a discussion on feedback and CBE typologies and maybe contribute to the

difference in overall mean effect size Table 2 lists the effect sizes in descending order of magnitude and its related CBI typology The MAIS is responsible for increasing achievement scores anywhere from 1 00 to 2 12 standard deviation units, with the exception of one effect size extracted from Schloss and colleagues (1988) Followed by a range of 0.03 to 0 99 standard deviations attributed to studies using a variety of CBI typologies such as CDIV, MAIS branching and linear CAI. These results seem to imply that advisement delivered via computer-based adaptive instructional systems (MAIS) constitutes the most effective feedback strategy in terms of achievement scores from immediate posttest administration. The use of an adaptive system involving the implementation of diagnostic and prescriptive instructional management system which accommodates the individual learning should facilitate acquisition of instructional objectives. The MAIS provided the most effective feedback strategy by advising the learner with the optimal amount of practice based on the learner's prior knowledge, criterion level of performance and "loss ratio". A second explanation for the highest effect sizes attributed to MAIS may also be explained by the learner's cognitive engagement resulting sufficient instructional activities such as adequate amounts of practice and examples provided by the system

Meta-Analysis

> In spite of the apparent flaws in the practice of meta-analysis,
> it remains the single most powerful tool for summarizing studies
> in an area of rapidly expanding literature (Bernard & Naidu, 1990).

Interpretation of Study Features

The features of studies involving both immediate and delayed posttest administration will be discussed according to importance and in comparison to previous research findings. The discussion will focus on the study features comprising the six categories of document characteristics, subject characteristics, instructional materials, criterion test, methodological features and feedback characteristics

Studies Involving Immediate Posttest Administration

The relationship between document source and effect size is, in fact, one of the best documented findings in the meta-analytic literature (Bangert-Drowns, Kulik & Kulik, 1984, Glass McGaw & Smith, 1981, Kulik & Kulik, 1989) Although not statistically different, the mean effect size for published journal articles exceeded the mean effect size for conference papers and dissertations. Explanations are still controversial but some attribute the difference to publication bias (Bernard & Naidu, 1990, Clark, 1985, Glass *et at.*, 1981) by accepting studies that apply more rigorous methods and often reject studies reporting no significant differences

The instructional materials category represented the most interesting category due to its significant results and therefore implications to the understanding of feedback Results of CBE typology which yielded a significant difference was related to the computerized lesson's adaptive capabilities. It seems that adaptive instruction, where the system engages in continuous monitoring of learner performance and provides advise concerning instructional content resulted in higher mean effect sizes followed by CDIV The statistical non significance of subject matter and instructional content are related to the significant mean effect sizes yielded when the researchers used an ISD model to design, develop and evaluate the content This was expected since it represents a fundamental principle in Educational Technology, to use an ISD model in the design development and evaluation of instructional materials (Dick & Carey, 1985, Gagne, 1985). Additional proof arised from the fact that the mean effect size of CBE materials reconstructed from previous materials was slightly, but not significantly higher than when materials were developed for study purposes only The slight enhancement of mean effect size for subjects who were introduced to the instructional unit may be related to orientation activities provided to the subjects prior to instructional unit, probably led to focus on the instructional content and prepared them with examples of unit responsiveness to their answers (e g., feedback messages, sequence of instruction, etc.) and thus averted the cognitive confusion usually associated with learning from an instructional unit Unit content in multiple formats seems to interfere with cognitive processes and thus lead to diminutive mean effect size In addition,

student accessibility to supplementary materials raise their achievement scores by nearly one and a quarter standard deviation which may be related to Clay's (1992) suggestion that hard copy summaries are recommended as memory aids to accompany computerized instructional units and thus ease the transferability to skills from the learner's knowledgebase to subsequent applications of involving the same material

Factors Contributing to Meta-Analytical Constraints

The meta-analysis presented in this thesis encompassed a synthesis of a subset of all studies that exist on the effects of feedback in computer-based education Factors such as the procedure used to collect the studies, availability of resources, choice of keywords, limited funding and lack of collegiality have all had a limiting influence on "what studies were to be synthesized" and thus, directly affected the results of this meta-analysis The limiting effects of each of these factors and ways to eliminate them will be discussed in great detail

The procedure used to collect the studies, both the ones that were included and excluded, from the meta-analysis had the greatest impact on the number of potential studies in this area The studies included and excluded from the meta-analysis are representative of the on-line and manual resources The keywords used during on-line searches were different and were database-dependent Although the thesauri of each database was used to ensure the use of all possible keywords, there were probably a number of studies that were not identified as potential candidates for the meta-analysis due to the selection of keywords used when the studies were initially incorporated onto the on-line databases.

The manual searches were restricted by limited access to the availability of books, journals and funds and lack of collegiality The availability of books and journals has a direct impact on the number of studies can be collected and thus included in the meta-analysis The problem of finding few recent acquisitions at Concordia University's libraries was remediated by procuring relevant books and journal articles at other universities such as McGill and Universite de Montreal Lack of funding was the greatest constraint since it limited the number of theses, dissertations and technical reports. For example, there were another thirty theses and

dissertations that were relevant but could not be purchased due to limited funds In addition, a surprisingly large amount of uncooperativeness existed amongst researchers who were contacted on several occasions and who failed to respond or to submit copies of their students theses and dissertations even when photocopying and mail expenditures were promised

Factors Affecting Meta-Analytical Results

There are other factors which affected the quantitative and qualitative results of a meta-analysis. Factors such as inclusion criteria, coding scheme used to categorize study features, and failure to recode studies by another individual.

The present study used Slavin's (1987) "best-evidence" meta-analytic approach in terms of initial collection of studies and restrictive inclusion criteria The meta-analysis followed Slavin's (1987) steps of conducting a broad-based preliminary literature search to understand the meaning and quality of evidence, formulate inclusion criteria and discuss excluded studies in some detail. The "best" in "best-evidence" method has been criticized by others (e g , Guskey, 1987) because who assert that the "best" in "best-evidence" is itself subjective and does not necessarily eliminate bias from the review Irrespective of criticism by qualitative researchers, the "best-evidence" method was applied in this study since the literature in the area of feedback effects on learning from CBE is riddled with numerous methodologically flawed studies In summary, this approach was deemed better suited than Glass's (1976) approach of including all studies on a given topic regardless of quality ("garbage in, garbage out") (Eysenck, 1987) which leads to a senseless distillation of markedly different studies.

The eighty-three (83) study features that comprised the coding scheme (see Appendix D) were often omitted due to a lack of description in individual studies The coding of each study never led to the coding of all possible study features since practically all studies suffered from a pervasive lack of description across all sections of each study. Hence, many study features including the subject, instructional materials, criterion test, methodological features and feedback characteristics were remained uncoded. The document characteristic comprised of the author name, year of publication, and document source was an exception since this type of information

was easily retrieved and coded This factor had a direct impact on the calculation of one-way ANOVAS between the individual categories within each study feature since most study features failed to add up to the possible 34 effect sizes

The studies should have been recoded by another person before proceeding to the effect size calculation Although, the researcher coded each study twice it would have been better practice to have someone else code independently and resolve any differences through discussion

Methodological Issues Affecting the Quality and Efficacy of a Meta-Analysis

Methodological issues and their effects on the outcome of the meta-analysis are discussed in terms of methodological irrelevance of multiple feedback groups, use of immediate and delayed feedback strategies with a single study and groups with small sample size The discussion will focus on the results presented in Table 3 The first study in Anderson *et al* (1971) investigated the effects of seven feedback schedules which resulted in the lowest effect size (ES=0 03) The resulting effect size may represent an example of "empirical uselessness" since it is probably more difficult for a statistical test to find statistical significance when the experimental conditions are not markedly different from each other

Two studies involved investigated the effects of both immediate and delayed feedback (Clariana *et al.*, 1991, Gaynor, 1981). The study by Clariana and colleagues (1991) compared three feedback groups KCR, AUC and delayed feedback to two control groups. The KCR informed the learners of their correct response after each answer, AUC presented KCR feedback following correct responses; and delayed feedback provided KCR-type feedback at the end of all four sections by presenting all forty questions with the correct answer Gaynor (1981) also compared three feedback groups, immediate, 30 second feedback and EOS The immediate feedback condition presented KCR feedback; 30 second feedback presented KCR feedback thirty seconds after responding to an item, and in the EOS condition subjects worked through the lesson before they received KCR. A comparison between these two studies involving both immediate and delayed feedback served to demonstrate the reason why the

literature in this area is comprised of contradictory findings and hence difficult to synthesize The first problem lies in the diversity of names used for feedback strategies In the above mentioned examples, the KCR (Clariana et al., 1991) condition and immediate condition (Gaynor, 1981) have two things in common. They both represent experimental conditions where subjects receive immediate KCR type feedback Similarly, the delayed feedback condition and EOS feedback were similar in the timing of feedback but differed in the feedback message Such methodological problems hamper the proper synthesis of studies in this area

The Dismal State of Educational Research

The dismal state of educational research is exemplified by the studies that were rejected from the quantitative meta-analysis. Thirty seven studies failed to meet the inclusion criteria since they displayed numerous methodological flaws The discussion will be based on the potential contribution or the reasons for exclusion of studies belonging to each category vis-a-vis their methodological flaws.

Eleven studies were rejected from the meta-analysis because of a lack of a control group. The presence of a control group constituted a fundamental element for the inclusion of a study into the meta-analysis Although, meta-analytic procedures for extracting effect sizes from studies lacking a control group (see Hunter & Schmidt, 1990) exist, no attempt was made to apply such techniques due to the confusion that existed regarding the misuse of feedback group's names and their corresponding strategies

One study involved the experimental comparison of four groups that contained small sample size. The generalization of the results are impossible due to the small sample size

Other studies, involving non-CBI control groups (n=4) and incomparable treatment groups (n=1) lack both internal and external validity (Campbell & Stanley, 1963) due to the inappropriateness of the groups selected by the researchers to compare the effect of computer-presented feedback.

In three studies subjects were allowed to select the feedback message after responding to an instructional item. These studies are fundamentally different since their hypotheses

investigated the feedback selection behaviors of subjects Also, they lack a true control group and feedback group from which effect sizes could be extracted

The effect sizes in this meta-analysis involved the conversion of achievement group scores (dependent measures) into standardized measures of effect size Two studies included measures of anxiety, number of steps per problem, identification per problem and time spent on each problem as the dependent measures. Their exclusion is based on the fact that achievement scores were not used as the dependent variable

Ormrod's (1986) study was excluded because negative feedback messages were presented to subjects whose spelling was outside the program's tolerance level. The true effects of feedback cannot be assessed experimentally when subjects in the control group are presented with feedback messages.

Three studies failed to provide sufficient statistical data or used an inappropriate statistical analysis to compare the data. As indicated by Asher (1990), there are few problems doing the arithmetic in meta-analysis, however, there are lots of problems in determining effect sizes since the basic statistics of means and standard deviation often are not reported.

The nature of the rejection of these studies can be attributed either to true methodological flaws or to incompatibility with the inclusion criteria (inappropriate dependent measures) The results of rejected studies exhibiting true methodological flaws such as the comparison of experimental groups without a control group, small sample size, non-CBI control group, subjects selected their own feedback message, incomparable treatment groups, feedback presented to control group and problems with data and statistical analyses are of no experimental value since they are littered with factors constituting threats to internal and external validity. Furthermore, they failed to contribute to the already existing empirical evidence on the effects of computer-presented feedback in CBI

Feedback, as described in the literature, differs in many respects including the researcher's orientation Domains such as cybernetics tend to define feedback, deviation limiting feedback, as the component of a system responsible for restoring equilibrium by minimizing

signal deviation through feedback loop that feeds back a portion of the output back into the input (Kefalas, Kefalas & Schoderbek, 1990) In retrospect, the definition of feedback has changed along with the areas focus from behaviorism to the more recent cognitive orientation As such, the idea of feedback-as-reinforcement has been replaced by recent information-processing theories which view feedback as providing corrective information

The operational definitions provided by researchers and theorists share common aspects of the construct. Feedback is a post-response message the learner receives The content of the feedback message may vary from a simple "yes" or "no" answer to an elaborate explanation of why the answer is incorrect and possible solution as how to find the correct answer. The mode of the message may be visual or aural, verbal or nonverbal

Future Research Directions on Feedback in CBI

The use of the computer as the deliverer of truly effective feedback will never be attained until it can be programmed to identify the cause of the user's mistakes rather than merely verify (e.g., correct or wrong) and explain the correct method

There are certain assumptions and fallacies inherent with present systems that makes the underlying empirical research futile at ever answering any questions concerning the effects of feedback in learning from CBI The first assumption is that the learner actually perceives the feedback message and cognitively processes it such a way that it actually motivates the learner and/or alters the mental model and thus rectify the misconception or mistake The second assumption is that feedback is necessary all the time. Does the learner really need feedback after every instructional response. Probably not, this may interfere with learning, and may constitute a case for delayed feedback. The third assumption, based on the experimental condition employed in feedback studies is that all subjects in a given feedback group will **always** receive the same feedback designated to that group For example, students assigned to an elaborative feedback group will always receive elaborate feedback regardless of their need for such a feedback strategy in response to their errors. This may be required according to experimental methodologies but nonsensical in terms of providing appropriate feedback at a given instructional

moment The fourth assumption is that a student error represents a misconception or error - maybe it isn't, maybe it was a product of carelessness an if so why deliver a feedback message?

Future empirical studies will have to employ different methodological approaches in the study of effective computer-presented feedback by using computer-based adaptive instructional systems. The effectiveness of the advisement strategies incorporated in computer-based adaptive instructional systems (e g , MAIS) has been examined in the present meta-analysis. The achievement gains extracted from studies using the MAIS seem to indicate that the key to successful advisement lies in the system's ability to advise the student regarding the selection of examples and practice items needed to reach mastery. The inherent strength of such a system's adaptiveness as related to the implementation of diagnostic and prescriptive instructional management strategies designed to make the learning experience more efficient, meaningful, and productive for the student

ITS might offer a solution since they have the ability to conduct on-line diagnosis of the learner and thus construct a potentially noise-free learner model and rectify any misconceptions through the application of pedagogical interventions The problems associated with the development of such systems included the time and funding required to construct such a system. More recently, Sleeman, Kelly, Martinak, Ward and Moore (1989) have challenged the educational credibility of the ITS approach. Comparison between human and ITS tutor by Nicolson (1992) have concluded that there is no statistical difference between both except that the subjects in the ITS tutor showed significant greater reduction in the number of bugs. The possible solution may exist in shifting the role of the computer as "the provider of instruction" which in most cases, including ITS's, cannot effectively identify the cause of the learner's mistakes (Nicolson, 1992) to a medium of information presentation where the teacher is responsible for the provision of adaptive quality of guidance and instruction expected of a human teacher

> The computer must capitalize on each student's failure as an opportunity to correct a misconception. If it merely tells a student that he is wrong, it has done no teaching at all, but has rather pushed the problem off to the student, who must somehow determine why he/she is wrong (Schank & Slade, 1985).

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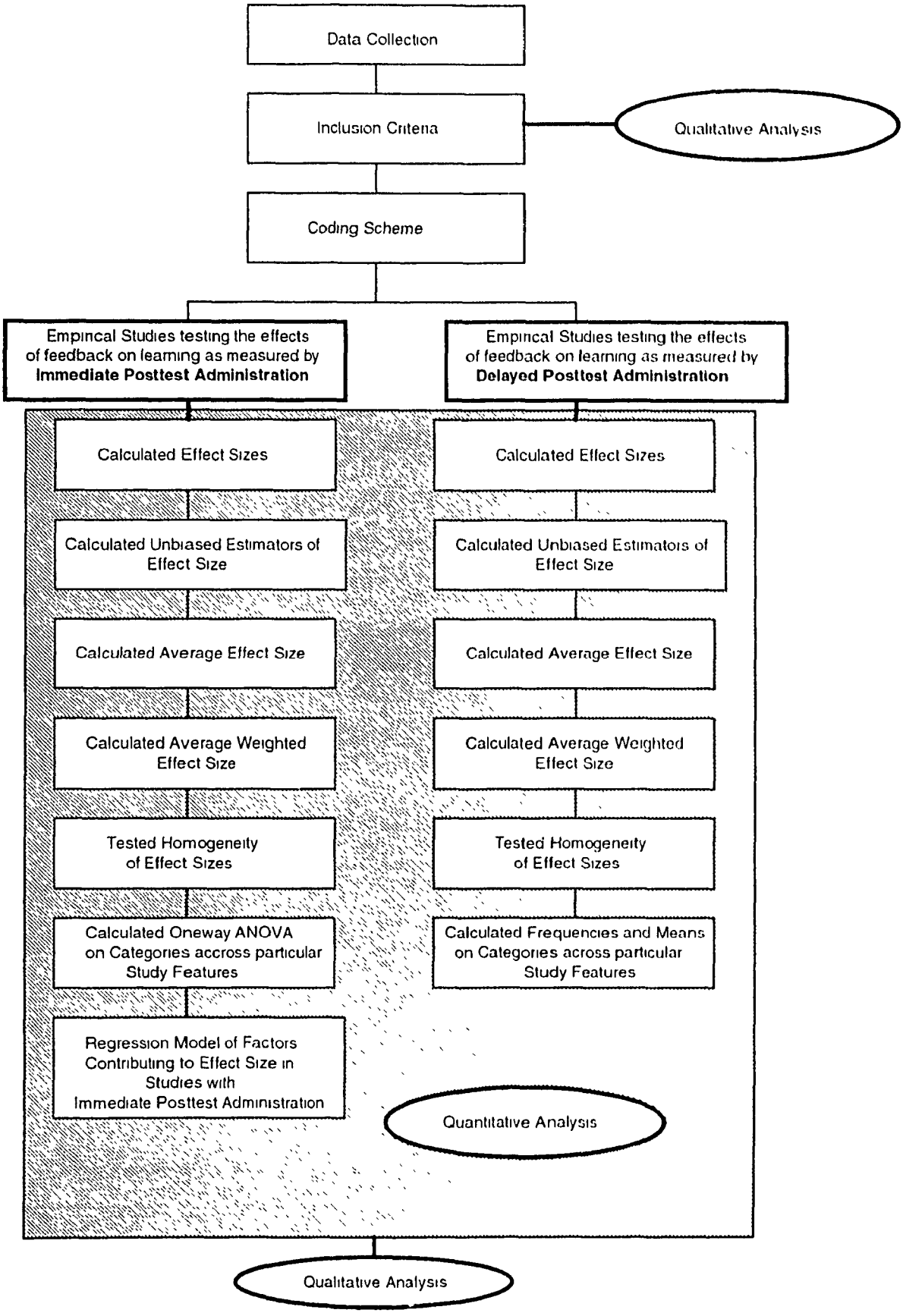
APPENDIX A

Overall Quantitative and Qualitative Meta-Analytic Approach


Data Collection
Inclusion Criteria
Qualitative Analysis
Coding Scheme
Empirical Studies testing the effects of feedback on learning as measured by **Immediate Posttest Administration**
Empirical Studies testing the effects of feedback on learning as measured by **Delayed Posttest Administration**
Calculated Effect Sizes
Calculated Unbiased Estimators of Effect Size
Calculated Average Effect Size
Calculated Average Weighted Effect Size
Tested Homogeneity of Effect Sizes
Calculated Oneway ANOVA on Categories accross particular Study Features
Regression Model of Factors Contributing to Effect Size in Studies with Immediate Posttest Administration
Calculated Effect Sizes
Calculated Unbiased Estimators of Effect Size
Calculated Average Effect Size
Calculated Average Weighted Effect Size
Tested Homogeneity of Effect Sizes
Calculated Frequencies and Means on Categories across particular Study Features
Quantitative Analysis
Qualitative Analysis

APPENDIX B

Information Sources, Keywords and Years Probed during On-Line Computer Searches

SOURCE	KEYWORDS	YEARS
ERIC	CAI CAI and feedback CAL CAL and feedback feedback knowledge of results review programmed instruction programmed instruction and feedback	January 1966 to December 1992
PsychLIT	CAI CAI and feedback CAL CAL and feedback feedback feedback in CAI computer based instruction and feedback and learning	January 1983 to December 1992
Social Citation Index	feedback feedback and computer assisted instruction	January 1966 to December 1992
MUSE	CAI CAL feedback knowledge of results reinforcement coaching	1860 to 1992

APPENDIX C

Information Sources, Keywords and Years Searched Manually

SOURCE	KEYWORDS	YEARS
Educational Technology Abstracts	feedback advisement coaching knowledge of results cueing confirmation CAI CAL knowledge-based systems artificial intelligent systems videodisc expert systems intelligent tutoring systems	1985 to 1992
British Education Index	CAL CAI feedback	July 1990 December 1992
Dissertation Abstracts International	feedback advisement coaching knowledge of results cueing confirmation CAI CAL knowledge-based systems artificial intelligent systems videodisc expert systems intelligent tutoring systems	1951 to 1992
Masters Abstracts	feedback advisement coaching knowledge of results cueing confirmation CAI CAL knowledge-based systems artificial intelligent systems videodisc expert systems intelligent tutoring systems	1972 to 1992
CIJE	CBI CAI feedback	1988 to 1992
AERA annual meeting handbook	feedback computer research computing CAI CAL CBI	1984 to 1992

APPENDIX D

Revised Coding Scheme used to Categorize Study Features

DOCUMENT CHARACTERISTICS

1. **Study Number**
   (could only be coded once all studies are coded and alphabetically organized)

2. **Authors**
   (Include first nine letters and digits indicating author, authors, and experiment number within the same experiment (e g., TENNYSON, TENNYETAL, TENNYSON1)

3. **Year of publication**
   (Insert the four digits of the calendar year)

4. **Document Source**
   1. Published journal article
   2. Conference paper
   3. Dissertation

SUBJECT CHARACTERISTICS

5. **Total Sample Size (N)**

6. **Experimental Group n size**

7. **Control Group n size**

8. **N used to calculate Effect Size**
   (In case of factorial designs, where only certain cells were utilized However, in other cases this number will equal Total Sample Size)

9. **Gender**
   1. Mixed/Unspecified

10. **Student Level**
    1. Average
    2. At risk Academically

11. **Academic Level**
    1. Primary School
    2. Secondary School
    3. College (Bachelor's, Master's, Ph D , post doctoral)
    4. Other (e.g., teacher training)

INSTRUCTIONAL MATERIALS

12. CBE typology

1 Linear CAI
2 MAIS (Minnesota Adaptive Instructional System)
3 Computer-driven Interactive Video
4 Drill & Practice
5 Branching CAI

13. Subject Matter Content

1 Medicine
2. Genetics
3 Relational Concepts
4 Arts/Museum
5. Multiplication Tables
6 Human Eye
7 Science
8 Matrix Algebra
9 Research Concepts
10 Metric Conversion
11 English composition/Grammar rules
12. Human Sexuality (Biology)
13. Statistical Concepts
14 TV production Special Effects
15 Special Education Services
16. Physics
17 Psychology

14. Used an Instructional Systems Design Model

1 Yes
2. No

15. Course (CBE) Materials Construction

1. Someone other than researcher
2 Experimenter/Researcher developed
3 Developed by other Teachers/Researchers
4 Developed by Teachers/Researchers

16. Type of Instructional Content

1 Concepts
2 Concepts & Factual
3. Rules
4 Verbal Information
5 Inferential Learning
6 Cognitive and Factual

17. Duration of Treatment (Insert the number of days)

18. Instructional Item Type
1 Mixed Types
2 Touch Screen
3 Multiple Choice
4. Completion

19. CBE materials are modified versions of preexisting materials
1. Yes
2. Unspecified

20. Subjects were introduced to instructional unit
1. Yes
2. No

21. Format of Unit Content
1. Text & Graphics
2. Graphics
3. Video, Slides and no Text
4. Text

22. Accessibility to supplemental instructional materials
1. Yes
2 No

CRITERION TEST

23. Administration Criterion Test
1. Paper-and-pencil
2. On-line
3. Orally

24. Test Material Construction (Control for Test-Author Bias)
1. Experimenter/Researcher Developed
2. Developed by others (experts, researchers)
3. Commercial Test
4. Teacher Developed

25. Task Domain
1. Verbal Information
2. Multiple Domains
3 Cognitive

26. Instructional Item Type
1. Mixed types of answers
2 Open-ended questions
3. Completion
4. Multiple choice
5 Free Response

27. Familiarity of Criterion Items
1. New Items
2 Criterion Items Appeared in Instruction
3 Criterion Items Appeared in Instruction but Randomized
4. Criterion Items Similar to Instructional Items
5. Criterion Items Similar to Instructional Items but Reworded

28. Timing of Criterion (in the Immediate Testing Condition)
1. Immediately after lesson
2. 10 Minutes after lesson

29. Timing of Criterion (in the Delayed Testing Condition)
1. 1 Day after lesson
2. 1 Week after lesson
3. 2 Weeks after lesson
4. 14-16 Weeks after lesson
5. Missing but administered

30. Validation of Test Items Performed by
1. Researcher
2. 2 Instructional Designers
3 Experts
4. 2 Independent Researchers

METHODOLOGICAL FEATURES

31. Sample Selection
1. Stratified and then Randomized
2. Random
3. Blocked and Randomized
4 Divided

32. Participation
1. Course Requirement (would affect final grades)
2. Volunteers (would not affect final grades)
3. Combination (1 & 2)

33. Study Duration (Insert number of days)

34. Overall Statistical Analysis
1. F
2. ANCOVA
3. F repeated measures
4. MANOVA & Univariate ANOVAs
5. MANOVA

FEEDBACK CHARACTERISTICS

35. Number of Feedback Groups (used to calculate Effect Size)

36. Number of Control Groups (used to calculate Effect Size)

37. Location of Feedback Message

1. Same Screen as Instruction
2. Separate Screen

38. Name of Control Group 1

01. 0% KCR
02. 0% standard
03. Control
04. Learner Control
05. NFB (no feedback)
06. Questions without feedback
07. No questions
08. Linear
09. Non-corrective feedback
10. Long Delay
11. Video
12. CL/NF (closed loop, no feedback)
13. FL/NF (forced loop, no feedback)
14. Learner Control Without Advisement
15. Adaptive Control Without Feedback
16. Text + Q (questions)
17. Video + Q (question)

39. Strategy Used in Control Group 1

1. No feedback presented after each item
2. Subject given complete control over sequencing, pacing, stopping, remediation, exiting (Learner Control)
3. No feedback presented following each response and presented next problem
4. Given new frame of instruction after each answer and certitude level
5. No feedback provided after each response and proceed to next problem after correct or wrong answer
6. Received informational feedback after entire presentation (atypical feedback condition)
7. Presentation of a linear videotape
8. Presentation of linear videotape plus questions

40. Name of Control Group 2

01. 0% KCR
02. 0% standard
03. Control
04. Learner Control
05. NFB (no feedback)
06. Questions without feedback
07. No questions
08. Linear
09. Non-corrective feedback
10. Long Delay
11. Video
12. CL/NF (closed loop, no feedback)
13. FL/NF (forced loop, no feedback)
14. Learner Control Without Advisement
15. Adaptive Control Without Feedback
16. Text + Q (questions)
17. Video + Q (question)

41. Strategy Used in Control Group 2

1. No feedback presented after each item
2. Subject given complete control over sequencing, pacing, stopping, remediation, and exiting (Learner Control)
3. No feedback presented following each response and presented next problem
4. Given new frame of instruction after each answer and certitude level
5. No feedback provided after each response and proceed to next problem after correct or wrong answer
6. Received informational feedback after entire presentation (atypical feedback condition)
7. Presentation of a linear videotape
8. Presentation of linear videotape plus questions

42. Name of Feedback Group 1

01. 100% KCR
02. KCR-R
03. 10% KCR-R
04. KCR-W
05. Time-Out
06. Correct
07. Voluntary
08. 100% Standard
09. Textual
10. Symbolic
11. Pictorial
12. Learner Control with Advisement
13. KOR (Knowledge of Results)
14. KOR+CP (Knowledge of Results plus Corrective Procedure)
15. Feedback
16. KCR (Knowledge of Results)
17. AUC (Answer Until Correct)
18. Delayed feedback
19. Immediate feedback
20. 30 second feedback
21. EOS (End of Session)
22. "Wrong" and "Correct" KCR
23. Response Contingent
24. Combination (16 & 22 & 23)
25. External Control Immediate Feedback
26. External Control Delayed Feedback
27. Internal Control Immediate Feedback
28. Internal Control Delayed Feedback
29. Corrective Feedback
30. Learner Control with Advisement
31. KR
32. KR + KCR
33. Video + questions
34. Video + questions + feedback
35. Fully interactive
36. CL/F (Closed loop, feedback)
37. FL/F (Forced loop, feedback)
38. Learner Control Adaptive
39. Learner Adaptive Control
40. Adaptive Control
41. Learner Partial Control
42. Adaptive Control with Advisement
43. Text + Q + F (question + feedback)
44. Combination (13 & 16 & 23)

43. General Strategy used in Feedback Group 1

01. Presented feedback after each item
02 No feedback after responding
03. Subject given total control and advisement provide guidance and encouraged curiosity
04 Received different feedback message based on (a)correctness of answer and, (b)confidence level
05. Received feedback regarding which response was correct
06. Identifies wrong answer as wrong
07. Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09. Feedback received concerning accuracy of answer
10. Feedback for correct and wrong answers, video branching until correct answer attained
11 Advise on the number of item needed for mastery, advise on what concept to see next
12. Continuously selected examples, and sequenced examples according to subject's performance
13. Assessed subject's progress for selection of examples
14. Advisement after each response
15. Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17. Received feedback after completion of lesson
18. Feedback presented at end of program regarding the number of correct responses subject made

44. Strategy used in Feedback Group 1 after Correct Answer

01 Presented feedback after correct answers only
02. Presented feedback after a percentage of correct answers only
03 No feedback presented
04. Presented feedback after each item
05. "CORRECT" displayed following response and proceeded to next problem
06 "CORRECT" displayed
07 Statement of praise followed by the answer
08. "Answer ____ is correct"
09. Received the word "RIGHT" after each response
10. "Answer ____ is correct" plus feedback appropriate to response
11 Received feedback concerning the response's correctness
12. "CORRECT" and feedback appropriate to response
13. Presented next screen of information
14. "GOOD, the correct answer is ____ " after each sentence and a 15 second delay
15 "GOOD, the correct answer is ____" after each sentence
16. Presented next inf screen of information

45. Strategy used in Feedback Group 1 after First Wrong Answer

01. No feedback presented after each wrong answer
02 time delay before presentation of feedback
03 Looped to same frame and try again
04. "WRONG" displayed following response and proceeded to next problem
05. "WRONG" then try again
06. "WRONG" with correct answer and forced to type letter of correct answer to continue
07. "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11. "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13. "WRONG" and feedback, "CORRECT ____" and explanation
14. Recycled through instruction and asked question again
15. Ability to see particular screen
16. Presented screen with relevant information
17. "NO, the correct answer is ____ " after each sentence and a 15 second delay
18. Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

46. Strategy used in Feedback Group 1 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next
3. "WRONG" and type letter corresponding to correct answer
4. Move to next screen of video
5. Indicate correct answer and move to next screen
6. Move to next screen of information

47. Name of Feedback Group 2

01. 100% KCR
02 KCR-R
03. 10% KCR-R
04. KCR-W
05. Time-Out
06. Correct
07. Voluntary
08 100% Standard
09. Textual
10. Symbolic
11. Pictorial
12. Learner Control with Advisement
13. KOR (Knowledge of Results)
14. KOR+CP (Knowledge of Results plus Corrective Procedure)
15. Feedback
16. KCR (Knowledge of Results)
17. AUC (Answer Until Correct)
18. Delayed feedback
19. Immediate feedback
20. 30 second feedback
21. EOS (End of Session)
22. "Wrong" and "Correct" KCR
23. Response Contingent
24. Combination (16 & 22 & 23)
25. External Control Immediate Feedback
26. External Control Delayed Feedback
27. Internal Control Immediate Feedback
28. Internal Control Delayed Feedback
29. Corrective Feedback
30. Learner Control with Advisement
31. KR
32. KR + KCR
33. Video + questions
34. Video + questions + feedback
35. Fully interactive
36. CL/F (Closed loop, feedback)
37. FL/F (Forced loop, feedback)
38. Learner Control Adaptive
39. Learner Adaptive Control
40. Adaptive Control
41. Learner Partial Control
42. Adaptive Control with Advisement
43. Text + Q + F (question + feedback)
44. Combination (13 & 16 & 23)

48. General Strategy used in Feedback Group 2

01. Presented feedback after each item
02. No feedback after responding
03 Subject given total control and advisement provide guidance and encouraged curiosity
04. Received different feedback message based on (a)correctness of answer and, (b)confidence level
05. Received feedback regarding which response was correct
06. Identifies wrong answer as wrong
07. Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09. Feedback received concerning accuracy of answer
10. Feedback for correct and wrong answers, video branching until correct answer attained
11 Advise on the number of item needed for mastery, advise on what concept to see next
12. Continuously selected examples, and sequenced examples according to subject's performance
13. Assessed subject's progress for selection of examples
14 Advisement after each response
15. Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17. Received feedback after completion of lesson
18. Feedback presented at end of program regarding the number of correct responses subject made

49. Strategy used in Feedback Group 2 after Correct Answer

01. Presented feedback after correct answers only
02. Presented feedback after a percentage of correct answers only
03. No feedback presented
04. Presented feedback after each item
05. "CORRECT" displayed following response and proceeded to next problem
06. "CORRECT" displayed
07. Statement of praise followed by the answer
08. "Answer ____ is correct"
09. Received the word "RIGHT" after each response
10. "Answer ____ is correct" plus feedback appropriate to response
11. Received feedback concerning the response's correctness
12. "CORRECT" and feedback appropriate to response
13. Presented next screen of information
14. "GOOD, the correct answer is ____ " after each sentence and a 15 second delay
15. "GOOD, the correct answer is ____" after each sentence
16. Presented next inf.screenscreen of information

50. Strategy used in Feedback Group 2 after First Wrong Answer

01 No feedback presented after each wrong answer
02 time delay before presentation of feedback
03. Looped to same frame and try again
04 "WRONG" displayed following response and proceeded to next problem
05. "WRONG" then try again
06. "WRONG" with correct answer and forced to type letter of correct answer to continue
07. "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11. "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13 "WRONG" and feedback, "CORRECT ____" and explanation
14. Recycled through instruction and asked question again
15. Ability to see particular screen
16 Presented screen with relevant information
17. "NO, the correct answer is ____ " after each sentence and a 15 second delay
18 Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

51. Strategy used in Feedback Group 2 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next problem
3. "WRONG" and type letter corresponding to correct answer
4. Move to next screen of video
5. Indicate correct answer and move to next screen
6 Move to next screen of information

52. Name of Feedback Group 3

01. 100% KCR
02. KCR-R
03. 10% KCR-R
04. KCR-W
05 Time-Out
06. Correct
07. Voluntary
08. 100% Standard
09. Textual
10. Symbolic
11. Pictorial
12. Learner Control with Advisement
13. KOR (Knowledge of Results)
14. KOR+CP (Knowledge of Results plus Corrective Procedure)
15. Feedback
16. KCR (Knowledge of Results)
17. AUC (Answer Until Correct)
18. Delayed feedback
19. Immediate feedback
20. 30 second feedback
21. EOS (End of Session)
22. "Wrong" and "Correct" KCR
23. Response Contingent
24. Combination (16 & 22 & 23)
25. External Control Immediate Feedback
26. External Control Delayed Feedback
27. Internal Control Immediate Feedback
28. Internal Control Delayed Feedback
29. Corrective Feedback
30. Learner Control with Advisement
31. KR
32. KR + KCR
33. Video + questions
34. Video + questions + feedback
35 Fully interactive
36. CL/F (Closed loop, feedback)
37. FL/F (Forced loop, feedback)
38. Learner Control Adaptive
39. Learner Adaptive Control
40. Adaptive Control
41. Learner Partial Control
42. Adaptive Control with Advisement
43. Text + Q + F (question + feedback)
44. Combination (13 & 16 & 23)

53. General Strategy used in Feedback Group 3

01 Presented feedback after each item
02 No feedback after responding
03 Subject given total control and advisement provide guidance and encouraged curiosity
04. Received different feedback message based on (a)correctness of answer and, (b)confidence level
05 Received feedback regarding which response was correct
06 Identifies wrong answer as wrong
07 Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09. Feedback received concerning accuracy of answer
10. Feedback for correct and wrong answers, video branching until correct answer attained
11 Advise on the number of item needed for mastery, advise on what concept to see next
12 Continuously selected examples, and sequenced examples according to subject's performance
13. Assessed subject's progress for selection of examples
14. Advisement after each response
15 Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17 Received feedback after completion of lesson
18 Feedback presented at end of program regarding the number of correct responses subject made

54. Strategy used in Feedback Group 3 after Correct Answer

01. Presented feedback after correct answers only
02 Presented feedback after a percentage of correct answers only
03. No feedback presented
04 Presented feedback after each item
05. "CORRECT" displayed following response and proceeded to next problem
06. "CORRECT" displayed
07. Statement of praise followed by the answer
08 "Answer ____ is correct"
09. Received the word "RIGHT" after each response
10. "Answer ____ is correct" plus feedback appropriate to response
11. Received feedback concerning the response's correctness
12. "CORRECT" and feedback appropriate to response
13 Presented next screen of information
14. "GOOD, the correct answer is ____ " after each sentence and a 15 second delay
15. "GOOD, the correct answer is ____" after each sentence
16. Presented next screen of information

55. Strategy used in Feedback Group 3 after First Wrong Answer

01. No feedback presented after each wrong answer
02 time delay before presentation of feedback
03. Looped to same frame and try again
04. "WRONG" displayed following response and proceeded to next problem
05. "WRONG" then try again
06. "WRONG" with correct answer and forced to type letter of correct answer to continue
07. "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11. "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13. "WRONG" and feedback, "CORRECT ____" and explanation
14. Recycled through instruction and asked question again
15. Ability to see particular screen
16. Presented screen with relevant information
17. "NO, the correct answer is ____" after each sentence and a 15 second delay
18. Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

56. Strategy used in Feedback Group 3 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next
3. "WRONG" and type letter corresponding to correct answer
4. Move to next screen of video
5. Indicate correct answer and move to next screen
6. Move to next screen of information

57. **Name of Feedback Group 4**

01. 100% KCR
02 KCR-R
03 10% KCR-R
04 KCR-W
05. Time-Out
06 Correct
07. Voluntary
08. 100% Standard
09 Textual
10. Symbolic
11 Pictorial
12. Learner Control with Advisement
13. KOR (Knowledge of Results)
14. KOR+CP (Knowledge of Results plus Corrective Procedure)
15. Feedback
16 KCR (Knowledge of Results)
17 AUC (Answer Until Correct)
18 Delayed feedback
19 Immediate feedback
20. 30 second feedback
21 EOS (End of Session)
22 "Wrong" and "Correct" KCR
23. Response Contingent
24. Combination (16 & 22 & 23)
25. External Control Immediate Feedback
26 External Control Delayed Feedback
27. Internal Control Immediate Feedback
28. Internal Control Delayed Feedback
29 Corrective Feedback
30 Learner Control with Advisement
31. KR
32. KR + KCR
33 Video + questions
34 Video + questions + feedback
35. Fully interactive
36 CL/F (Closed loop, feedback)
37 FL/F (Forced loop, feedback)
38. Learner Control Adaptive
39 Learner Adaptive Control
40 Adaptive Control
41 Learner Partial Control
42 Adaptive Control with Advisement
43. Text + Q + F (question + feedback)
44 Combination (13 & 16 & 23)

58. General Strategy used in Feedback Group 4

01 Presented feedback after each item
02 No feedback after responding
03. Subject given total control and advisement provide guidance and encouraged curiosity
04 Received different feedback message based on (a)correctness of answer and, (b)confidence level
05. Received feedback regarding which response was correct
06 Identifies wrong answer as wrong
07. Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09. Feedback received concerning accuracy of answer
10 Feedback for correct and wrong answers, video branching until correct answer attained
11. Advise on the number of item needed for mastery, advise on what concept to see next
12 Continuously selected examples, and sequenced examples according to subject's
13. Assessed subject's progress for selection of examples
14. Advisement after each response
15. Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17. Received feedback after completion of lesson
18. Feedback presented at end of program regarding the number of correct responses subject made

59. Strategy used in Feedback Group 4 after Correct Answer

01. Presented feedback after correct answers only
02. Presented feedback after a percentage of correct answers only
03. No feedback presented
04. Presented feedback after each item
05. "CORRECT" displayed following response and proceeded to next problem
06. "CORRECT" displayed
07. Statement of praise followed by the answer
08. "Answer ____ is correct"
09. Received the word "RIGHT" after each response
10 "Answer ____ is correct" plus feedback appropriate to response
11. Received feedback concerning the response's correctness
12. "CORRECT" and feedback appropriate to response
13. Presented next screen of information
14. "GOOD, the correct answer is ____ " after each sentence and a 15 second delay
15. "GOOD, the correct answer is ____" after each sentence
16. Presented next screen of information

60. Strategy used in Feedback Group 4 after First Wrong Answer

01 No feedback presented after each wrong answer
02 time delay before presentation of feedback
03 Looped to same frame and try again
04. "WRONG" displayed following response and proceeded to next problem
05 "WRONG" then try again
06 "WRONG" with correct answer and forced to type letter of correct answer to continue
07 "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11 "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13 "WRONG" and feedback, "CORRECT ____" and explanation
14. Recycled through instruction and asked question again
15. Ability to see particular screen
16. Presented screen with relevant information
17 "NO, the correct answer is ____ " after each sentence and a 15 second delay
18. Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

61. Strategy used in Feedback Group 4 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next
3. "WRONG" and type letter corresponding to correct answer
4 Move to next screen of video
5. Indicate correct answer and move to next screen
6. Move to next screen of information

62. Name of Feedback Group 5

01. 100% KCR
02. KCR-R
03. 10% KCR-R
04. KCR-W
05. Time-Out
06. Correct
07. Voluntary
08. 100% Standard
09. Textual
10. Symbolic
11. Pictorial
12. Learner Control with Advisement
13. KOR (Knowledge of Results)
14. KOR+CP (Knowledge of Results plus Corrective Procedure)
15. Feedback
16. KCR (Knowledge of Results)
17. AUC (Answer Until Correct)
18. Delayed feedback
19. Immediate feedback
20. 30 second feedback
21. EOS (End of Session)
22. "Wrong" and "Correct" KCR
23. Response Contingent
24. Combination (16 & 22 & 23)
25. External Control Immediate Feedback
26. External Control Delayed Feedback
27. Internal Control Immediate Feedback
28. Internal Control Delayed Feedback
29. Corrective Feedback
30. Learner Control with Advisement
31. KR
32. KR + KCR
33. Video + questions
34. Video + questions + feedback
35. Fully interactive
36. CL/F (Closed loop, feedback)
37. FL/F (Forced loop, feedback)
38. Learner Control Adaptive
39. Learner Adaptive Control
40. Adaptive Control
41. Learner Partial Control
42. Adaptive Control with Advisement
43. Text + Q + F (question + feedback)
44. Combination (13 & 16 & 23)

63. General Strategy used in Feedback Group 5

01. Presented feedback after each item
02. No feedback after responding
03. Subject given total control and advisement provide guidance and encouraged curiosity
04. Received different feedback message based on (a)correctness of answer and, (b)confidence level
05. Received feedback regarding which response was correct
06. Identifies wrong answer as wrong
07. Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09. Feedback received concerning accuracy of answer
10. Feedback for correct and wrong answers, video branching until correct answer attained
11. Advise on the number of item needed for mastery, advise on what concept to see next
12. Continuously selected examples, and sequenced examples according to subject's
13. Assessed subject's progress for selection of examples
14 Advisement after each response
15. Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17. Received feedback after completion of lesson
18. Feedback presented at end of program regarding the number of correct responses subject made

64. Strategy used in Feedback Group 5 after Correct Answer

01 Presented feedback after correct answers only
02. Presented feedback after a percentage of correct answers only
03. No feedback presented
04. Presented feedback after each item
05 "CORRECT" displayed following response and proceeded to next problem
06. "CORRECT" displayed
07 Statement of praise followed by the answer
08. "Answer ____ is correct"
09. Received the word "RIGHT" after each response
10 "Answer ____ is correct" plus feedback appropriate to response
11. Received feedback concerning the response's correctness
12. "CORRECT" and feedback appropriate to response
13 Presented next screen of information
14. "GOOD, the correct answer is ____ " after each sentence and a 15 second delay
15. "GOOD, the correct answer is ____" after each sentence
16 Presented next screen of information

65. Strategy used in Feedback Group 5 after First Wrong Answer

01. No feedback presented after each wrong answer
02. time delay before presentation of feedback
03. Looped to same frame and try again
04. "WRONG" displayed following response and proceeded to next problem
05. "WRONG" then try again
06. "WRONG" with correct answer and forced to type letter of correct answer to continue
07. "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11. "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13. "WRONG" and feedback, "CORRECT ____" and explanation
14. Recycled through instruction and asked question again
15. Ability to see particular screen
16. Presented screen with relevant information
17. "NO, the correct answer is _____ " after each sentence and a 15 second delay
18. Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

66. Strategy used in Feedback Group 5 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next
3. "WRONG" and type letter corresponding to correct answer
4. Move to next screen of video
5. Indicate correct answer and move to next screen
6. Move to next screen of information

67. **Name of Feedback Group 6**
    01. 100% KCR
    02 KCR-R
    03. 10% KCR-R
    04. KCR-W
    05. Time-Out
    06. Correct
    07. Voluntary
    08. 100% Standard
    09. Textual
    10. Symbolic
    11. Pictorial
    12. Learner Control with Advisement
    13. KOR (Knowledge of Results)
    14. KOR+CP (Knowledge of Results plus Corrective Procedure)
    15. Feedback
    16. KCR (Knowledge of Results)
    17. AUC (Answer Until Correct)
    18 Delayed feedback
    19. Immediate feedback
    20. 30 second feedback
    21. EOS (End of Session)
    22. "Wrong" and "Correct" KCR
    23. Response Contingent
    24. Combination (16 & 22 & 23)
    25. External Control Immediate Feedback
    26. External Control Delayed Feedback
    27. Internal Control Immediate Feedback
    28. Internal Control Delayed Feedback
    29. Corrective Feedback
    30. Learner Control with Advisement
    31 KR
    32. KR + KCR
    33. Video + questions
    34. Video + questions + feedback
    35. Fully interactive
    36. CL/F (Closed loop, feedback)
    37. FL/F (Forced loop, feedback)
    38. Learner Control Adaptive
    39. Learner Adaptive Control
    40 Adaptive Control
    41 Learner Partial Control
    42. Adaptive Control with Advisement
    43. Text + Q + F (question + feedback)
    44. Combination (13 & 16 & 23)

68. General Strategy used in Feedback Group 6

01. Presented feedback after each item
02 No feedback after responding
03. Subject given total control and advisement provide guidance and encouraged curiosity
04. Received different feedback message based on (a)correctness of answer and, (b)confidence level
05. Received feedback regarding which response was correct
06. Identifies wrong answer as wrong
07. Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09. Feedback received concerning accuracy of answer
10. Feedback for correct and wrong answers, video branching until correct answer attained
11. Advise on the number of item needed for mastery, advise on what concept to see next
12. Continuously selected examples, and sequenced examples according to subject's performance
13. Assessed subject's progress for selection of examples
14. Advisement after each response
15. Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17 Received feedback after completion of lesson
18. Feedback presented at end of program regarding the number of correct responses subject made

69. Strategy used in Feedback Group 6 after Correct Answer

01 Presented feedback after correct answers only
02. Presented feedback after a percentage of correct answers only
03. No feedback presented
04. Presented feedback after each item
05. "CORRECT" displayed following response and proceeded to next problem
06. "CORRECT" displayed
07 Statement of praise followed by the answer
08. "Answer ____ is correct"
09 Received the word "RIGHT" after each response
10. "Answer ____ is correct" plus feedback appropriate to response
11. Received feedback concerning the response's correctness
12. "CORRECT" and feedback appropriate to response
13. Presented next screen of information
14. "GOOD, the correct answer is ____ " after each sentence and a 15 second delay
15. "GOOD, the correct answer is ____" after each sentence
16. Presented next screen of information

70. Strategy used in Feedback Group 6 after First Wrong Answer

01 No feedback presented after each wrong answer
02. time delay before presentation of feedback
03. Looped to same frame and try again
04. "WRONG" displayed following response and proceeded to next problem
05 "WRONG" then try again
06. "WRONG" with correct answer and forced to type letter of correct answer to continue
07 "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11. "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13. "WRONG" and feedback, "CORRECT ____" and explanation
14. Recycled through instruction and asked question again
15. Ability to see particular screen
16. Presented screen with relevant information
17 "NO, the correct answer is ____ " after each sentence and a 15 second delay
18. Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

71. Strategy used in Feedback Group 6 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next
3. "WRONG" and type letter corresponding to correct answer
4. Move to next screen of video
5 Indicate correct answer and move to next screen
6. Move to next screen of information

72. **Name of Feedback Group 7**

01. 100% KCR
02. KCR-R
03. 10% KCR-R
04. KCR-W
05. Time-Out
06. Correct
07. Voluntary
08. 100% Standard
09. Textual
10. Symbolic
11. Pictorial
12. Learner Control with Advisement
13. KOR (Knowledge of Results)
14. KOR+CP (Knowledge of Results plus Corrective Procedure)
15. Feedback
16. KCR (Knowledge of Results)
17. AUC (Answer Until Correct)
18. Delayed feedback
19. Immediate feedback
20. 30 second feedback
21. EOS (End of Session)
22. "Wrong" and "Correct" KCR
23. Response Contingent
24. Combination (16 & 22 & 23)
25. External Control Immediate Feedback
26. External Control Delayed Feedback
27. Internal Control Immediate Feedback
28. Internal Control Delayed Feedback
29. Corrective Feedback
30. Learner Control with Advisement
31. KR
32. KR + KCR
33. Video + questions
34. Video + questions + feedback
35. Fully interactive
36. CL/F (Closed loop, feedback)
37 FL/F (Forced loop, feedback)
38. Learner Control Adaptive
39. Learner Adaptive Control
40. Adaptive Control
41. Learner Partial Control
42. Adaptive Control with Advisement
43. Text + Q + F (question + feedback)
44. Combination (13 & 16 & 23)

73. General Strategy used in Feedback Group 7

01 Presented feedback after each item
02. No feedback after responding
03. Subject given total control and advisement provide guidance and encouraged curiosity
04. Received different feedback message based on (a)correctness of answer and, (b)confidence level
05. Received feedback regarding which response was correct
06 Identifies wrong answer as wrong
07 Presents knowledge of results feedback (correct and wrong), correct answer, correctly punctuated sentence, identification of rule
08. Correct answer stated in context of question
09 Feedback received concerning accuracy of answer
10. Feedback for correct and wrong answers, video branching until correct answer attained
11. Advise on the number of item needed for mastery, advise on what concept to see next
12. Continuously selected examples, and sequenced examples according to subject's performance
13. Assessed subject's progress for selection of examples
14. Advisement after each response
15. Provided feedback after instructional unit by presenting questions and the correct answer for each (30 minute delay)
16. Received feedback 30 seconds after responding to an item
17. Received feedback after completion of lesson
18. Feedback presented at end of program regarding the number of correct responses subject made

74. Strategy used in Feedback Group 7 after Correct Answer

01. Presented feedback after correct answers only
02 Presented feedback after a percentage of correct answers only
03. No feedback presented
04 Presented feedback after each item
05. "CORRECT" displayed following response and proceeded to next problem
06. "CORRECT" displayed
07. Statement of praise followed by the answer
08 "Answer ____ is correct"
09. Received the word "RIGHT" after each response
10 "Answer ____ is correct" plus feedback appropriate to response
11. Received feedback concerning the response's correctness
12 "CORRECT" and feedback appropriate to response
13. Presented next screen of information
14. "GOOD, the correct answer is _____ " after each sentence and a 15 second delay
15. "GOOD, the correct answer is _____" after each sentence
16. Presented next screen of information

75. Strategy used in Feedback Group 7 after First Wrong Answer

01. No feedback presented after each wrong answer
02. time delay before presentation of feedback
03 Looped to same frame and try again
04. "WRONG" displayed following response and proceeded to next problem
05. "WRONG" then try again
06. "WRONG" with correct answer and forced to type letter of correct answer to continue
07. "NO, TRY AGAIN" displayed on the bottom of the screen
08. "WRONG" after each response
09. showed remedial sequence, provided correct answer, briefly explained how correct answer was arrive, displayed related part of text
10. received feedback concerning incorrectness of answer
11. "ANSWER ___ is correct"
12. "ANSWER ___ is correct" and explanation
13. "WRONG" and feedback, "CORRECT ____" and explanation
14 Recycled through instruction and asked question again
15. Ability to see particular screen
16. Presented screen with relevant information
17 "NO, the correct answer is ____ " after each sentence and a 15 second delay
18. Presented feedback after wrong answers only
19. "NO, the correct answer is ___" after each sentence

76. Strategy used in Feedback Group 7 after Second Wrong Answer

1. Presented feedback
2. Informed of correct response, required subject to type correct answer, presented next
3. "WRONG" and type letter corresponding to correct answer
4. Move to next screen of video
5. Indicate wrong answer and move to next screen
6. Move to next screen of information

77. Effect Size 1 for Immediate Criterion Test Administration
(Insert five digit number, e g., -0.56, +1.23)

78. Effect Size 2 for Immediate Criterion Test Administration
(Insert five digit number, e.g., -0.56, +1.23)

79. Effect Size 3 for Immediate Criterion Test Administration
(Insert five digit number, e g., -0.56, +1 23)

80. Effect Size 4 for Immediate Criterion Test Administration
(Insert five digit number, e g., -0.56, +1.23)

81. Effect Size 1 for Delayed Criterion Test Administration
(Insert five digit number, e.g., -0 56, +1 23)

82. Effect Size 2 for Delayed Criterion Test Administration
(Insert five digit number, e g , -0.56, +1.23)

83. Effect Size 3 for Delayed Criterion Test Administration
(Insert five digit number, e.g., -0.56, +1.23)

APPENDIX E

Studies Rejected from the Meta-Analysis (n=37)

Arnett, P. P (1985) Effects of feedback placement and completeness within Gagne's model for computer assisted instruction lesson development on concept and rule learning Unpublished doctoral dissertation, University of Georgia

Carrier, C A., & Sales, G. C (1987) Pair versus individual work on the acquisition on concepts in a computer-based instructional lesson Journal of Computer-Based Instruction, 14(1), 11-17

Collins, M., Carnine, D., & Gersten, R (1987) Elaborated corrective feedback and the acquisition of reasoning skills. A study of computer-based instruction Exceptional Children, 54(3), 254-262

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APPENDIX F

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2 study comprised of 2 experiments

APPENDIX G

Steps Involved in the Calculation of the Weighted Mean Effect Size for Studies Involving Immediate Posttest Administration

Study #	N	d	d'^2	$1-d'^2$	w	wd'
1	168	0.00	0.00	1 00	168.13	4.71
3	48	0 43	0.18	0.82	58 89	25 32
4	46	0.46	0.21	0.79	58.35	26.84
4	44	0.54	0.29	0.71	62 11	33.54
4	45	0.45	0.20	0.78	56.43	25.39
5	52	0 18	0.03	0 97	53.74	9.67
6	41	0.12	0.01	0.99	41.60	4.99
7	120	0 77	0.59	0 41	294 77	226.97
8	100	0.80	0 64	0.36	277.78	222.22
9	42	0.42	0.18	0.82	50.99	21.42
9	42	0.55	0 30	0.70	60.22	33.12
10	92	0.22	0.05	0.95	96.68	21.27
10	92	0 20	0 04	0.96	95.83	19.17
10	92	0.15	0.02	0.98	94 12	14 12
11	75	0.46	0.21	0.79	95 13	43.76
12	75	0.38	0.14	0.86	87.66	33.31
13	221	0.07	0.01	0.99	222 09	15.55
14	41	0.14	0.02	0.98	41.82	5.85
15	32	1 48	2.19	-1.19	-26 88	-39.78
15	32	1.94	3 76	-2.76	-11.58	-22.47
15	32	2.12	4.50	-3.49	-9.16	-19.42
16	3(	0.92	0.85	0.15	234.38	215.63
17	98	0 99	0.98	0.02	4924 62	4875 37
18	25	0.40	0.16	0.84	29 76	11.90
18	25	0.31	0.10	0 90	27.66	8.57
18	25	0 57	0.32	0.68	37.03	21 11
18	25	1.37	1.88	-0.88	-28.51	-39.06
19	46	1.81	3.28	-2 28	-20.21	-36.58
19	46	0 93	0 86	0.14	340.49	316.66
20	63	1 63	2.66	-1.66	38.02	-61.98
21	47	0.90	0.81	0.19	247.37	222.63
21	47	1 00	1.00	0.00	0.00	0.00
21	47	1 36	1.85	-0.85	-55.32	-75.04
22	139	0 69	0.48	0.52	265 32	183.07
					7909.33	**6347.83**

weighted mean effect size = $\bar{d}' = \frac{\sum w_i d'_i}{\sum w_i} = \frac{8347\ 83}{7909\ 33} = 0\ 80$

APPENDIX H

Steps Involved in the Calculation of the Weighted Mean Effect Size for Studies Involving Delayed Posttest Administration

Study #	N	d	d'^2	$1-d'^2$	w'	w'd'
2	50	0.62	0.38	0.62	81.22	50.36
4	46	0.30	0.09	0 91	50.55	15.16
4	44	0.42	0.18	0.82	53.42	22.44
4	45	0.28	0.08	0.92	48.83	13.67
7	103	0.26	0.07	0.93	110.47	28.72
8	100	0.60	0 36	0.64	156.25	93.75
10	92	0.18	0.03	0.97	95.08	17.11
10	92	0.22	0.05	0.95	96.68	21.27
10	92	0.15	0.02	0.98	94.12	14.12
					786.62	**276.60**

weighted mean effect size = $\bar{d}' = \frac{\sum w_i d'_i}{\sum w_i} = \frac{276.60}{786\ 62} = 0\ 35$