THE USE OF FEEDBACK IN WEB-BASED INSTRUCTION: ACHIEVEMENT, FEEDBACK STUDY TIME, AND EFFICIENCY

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ABSTRACT

The purpose of this research study is to compare the effects of an instructional treatment that presented adaptive feedback based on students' perceptions about their answer correctness with a nonadaptive treatment on student performance, feedback study time, and lesson efficiency in a computer-based environment. Because of advances in technology, the instruction was delivered in a Web-based environment. Two versions of the Web-based lesson were designed. The lesson consisted of a pretest, a tutorial, and a posttest. The pre- and posttest were similar in that they tested students' ability to classify defined concepts, a higher cognitive task. The tutorial presented instructional text with inserted verbal information questions. Undergraduate volunteers enrolled in entry level education courses in the Watson School of Education were randomly assigned to one of the two treatment groups. One group received varied feedback information based upon the combined assessment of response correctness and the student's response certitude. The other group received feedback information that did not vary. Results indicate that the effects of adaptive feedback were not significantly different from the effects of nonadaptive feedback on concept learning. In the adaptive group, high certitude wrongs, low certitude corrects, and low certitude wrong responses resulted in higher feedback study time than high certitude correct responses. High certitude significantly correlated with fine discrimination errors in concept learning. In terms of feedback efficiency, adaptive feedback was significantly more efficient than nonadaptive feedback; however, for overall lesson efficiency, there were no significant differences between the two treatment groups. These results are discussed in terms of cost-benefit implications for the

design of effective Web-based instruction. Implications for future research are discussed in reference to results of this study and past research.

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DEDICATION

I would like to dedicate this thesis to my grandson, Niccolo, and any siblings he may have in the future. I would like for them to know that I will always support their academic efforts and pursuit of knowledge.

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INTRODUCTION

Overview

The Impact of Technological Advances on Education

Technology, in any field, exists because of human effort, and it is the workhorse of society and human endeavor. It is rarely, if ever, developed just for the sake of having it. The desire to make life better for the present and future generations is woven through the fabric of human existence. For example, the invention of Guttenberg's printing press changed communications forever. With this technological development, the written word could be spread among the masses more economically than ever before. Regardless of how monumental the printing press was, it pales in comparison to the development of the Internet and the World Wide Web. At the present time the speed at which technology advances approaches exponential proportions. Today, new technology arrives practically on the heels of its predecessor (http://www.c-i-a.com/).

Simultaneous to the evolution of educational technology was the evolution of distance education which began in the 19th century (Matthews, 1999). Instructional technology moved from slate to screen and gave rise to Skinner's programmed instruction (1958). With the increasing usage of personal computers in educational environments, training and education became portable and more cost effective. The demand for information and its easy access in business, industry, government, and the military helped revolutionize the way such institutions conduct their business. This demand, combined with the developments in news and entertainment, proved a boon for education as well. For example, the inventory of multimedia resources and equipment in schools has certainly changed over time. Overhead projectors, film and filmstrip projectors, and televisions were part of the evolution toward the current computer labs in

schools today. As the demand for technology in the marketplace drives costs down, technological advancements become more affordable in educational environments.

The rise of the World Wide Web as a viable training and learning delivery platform has made educational opportunities available literally anytime, anywhere. While telephone lines or broadband cables connect most Internet users to the Web, the next technological leap will likely involve advances in portability. Cellular telephones ushered in the most popular form of widespread wireless use. Universities and large business communities have installed systems of "portals" to provide seamless connectivity to intranets or the Internet, enabling users to be free from physical cables or direct connections. The explosion of growth of such technologies has vast implications for the future of educational opportunities. King and Behnke (1999) point out a subtle, yet important, benefit of using electronically-mediated teaching aids—the exposure to the technology itself. They state, "Electronic devices are the common tools of the information age" (p. 45). When students are exposed to these tools through formal education, they become more comfortable with the "inevitable twenty-first century amalgamation of informational and technological sciences" (King & Behnke, 1999, p. 45).

Feedback and Instruction

No matter what the broader purpose of education is, learning takes place at the individual level. When the learner demonstrates the acquisition of a prescribed ability or skill set, learning has occurred. One mechanism that facilitates efficient and effective acquisition of those abilities or skills sets is feedback (Gagné, 1985). Rarely does the learner acquire knowledge by osmosis; rather the learner should be actively engaged in

the learning process. Feedback facilitates and encourages active engagement by the learner. According to Estes (as cited in Gagné & Medsker, 1996), feedback is useful to the learner because it conveys information that the learning goal has been reached or is relatively near. When provided within the framework of the lesson, feedback serves as reinforcement and makes correct responses more likely to occur in the future. Mory (1992) states that feedback provides "interactions that result in mutual influence between learners and their environment" (p. 18). Instructional feedback is information that is provided to the learner with the intent of verifying the degree of correctness of specific responses, helping the learner correct errors and misconceptions, and aiding the learner in retaining correct responses in memory.

An interactive multimedia environment such as the World Wide Web requires the same quality of feedback design as does the traditional classroom delivery method. While the Web has the capability of providing instant feedback, not every learning situation requires instant responses. Feedback should support the purpose and needs of the specific learning type and unique situation.

Types of Feedback

Web-based programs have the capability of providing the learner with any kind and amount of feedback that designers feel appropriate in a particular learning setting. Feedback that supplies more than "yes or no" or "right or wrong" information is referred to as "elaboration" or "elaborated feedback." Verification has to do with providing the learner with the correctness of his or her response. Elaboration is the mechanism by which feedback accomplishes its broader purpose, which is to help the learner correct and retain what is learned. Designers may choose feedback that provides information from

the presented lesson material explaining why a particular response is correct or not, or it may even provide new material not presented in the lesson to help the learner better understand his or her misconception about the topic. Prior studies on various types of feedback have produced mixed results (Litchfield, Driscoll, & Dempsey,1990; Mory, 1992; Dempsey & Driscoll, 1993.). Further research is needed to help tease out relationships between types of feedback and improved learning. Moreover, traditional types of feedback have not been examined in a Web-based learning environment.

Response Certitude

One interesting variable that has come under scrutiny within the study of feedback and has also been linked to feedback's potential corrective functions is the learner's level of confidence in a particular response. This response confidence, sometimes referred to as *response certainty* or *response certitude,* is the learner's basic feeling of confidence in the correctness of his or her response. Learners have an idea of how much they know about a particular topic based on metacognitive awareness of their own prior knowledge base. It is this self-possessed knowledge that helps them assign a particular degree of certainty about individual responses. Previous studies (Kulhavy, Yekovick & Dyer, 1976; Kulhavy & Stock, 1989; Mory, 1991, 1994) have shown that the correctness of a response combined with the degree of certainty assigned to it directly impact the amount of time spent studying feedback. This relationship between response correctness and certitude has been found to have implications for how well feedback is processed, as well as what types of feedback would prove most efficient within the lesson.

Learning Types

Not all learning is the same. Learning how to solve a complex mathematics problem is different from learning the alphabet. Nor does learning occur in isolated "bubbles" in time, but is separated from the natural growth process in children. According to Gagné (1985),

> *Learning is a change in human disposition or capability that persists over a period of time and is not simply ascribable to processes of growth.* The kind of change called learning exhibits itself as a change in behavior, and the inference of learning is made by comparing what behavior was possible before the individual was placed in a *learning situation* and what behavior can be exhibited after such treatment" (p. 2).

He stresses that there should be a change in performance after instruction. Based on Gagné, one could assume that all learning is dependent upon prior knowledge. While we do not know exactly the amount of prior knowledge we are born with, it is assumed that normal newborns begin life with capabilities that are "age appropriate."

Among Gagné's taxonomy (1977 & 1985) for defining human capabilities are *intellectual skills* and *verbal information.* Basic forms of learning include associations and chains. The lowest subcategory of intellectual skills is *discrimination*, which must be demonstrated before the acquisition of *concepts. Rules* require *concepts* as a prerequisite. *Rules*, furthermore, serve as a prerequisite for *higher-order* rules.

Verbal information serves as an accompaniment and aid to learning. Human adults are expected to retain certain "common knowledge" information, such as days of the weeks, months of the year, pertinent geographic locations, to name a few. Certain professions require broad bases of organized information and specialized knowledge required by experts in their fields (Gagné, 1977). "Just as intellectual skills come in

varieties that are more or less complex, one might expect similar degrees of complexity among sets of information" (Gagné, 1977, p. 61).

While many types of learning occur in various subject areas and environments, the focus of this study is specifically on the learning outcomes of "concepts" (an intellectual skill) as compared to simple "verbal information." In much of the research examining feedback type (Kulhavy, Yekovich & Dyer,1976; Kulhavy et al., 1979; Kulhavy & Stock, 1989), there have been variations on how well feedback's corrective function is utilized under different learning conditions.

Statement of the Problem

The purpose of this study is to examine various types of feedback presented in a Web-based instructional environment on the learning of verbal information tasks and the acquisition and classification of defined concepts. The Web-based environment has not been researched in this area. Additionally, the learning task that will be presented via the Web involves introducing undergraduate students to information about nine learning capabilities (verbal information) typically employed in information-processing and instructional design practices. The module then allows students to practice classifying various examples of learning (defined concepts). It is the second task of classification that tends to be most confusing for students. It is one matter for students to learn about the nine learning capabilities, but the task of successfully recognizing and classifying the learning capability involves a higher intellectual skill task.

Learner response certitude will also be examined to compare feedback adaptations based upon a combination of answer correctness and learner level of certitude. Adaptive feedback has implications for both efficiency and effectiveness of feedback on learner's

achievement because feedback content may be altered in its length and type to result in quicker feedback study times and/or higher levels of achievement.

In addition, for concept items, an examination of the type of errors that occur will be classified according to categories of "fine" and "gross" discrimination errors**.** In their discussion of intellectual skills, Gagné and Medsker (1996) present a "learning hierarchy" as a psychological organization of this condition of learning. Each level in the hierarchy including discrimination, concrete concepts, defined concepts, and rule learning is prerequisite to the following level. In their 1993 study, Dempsey and Driscoll examined the relationship between discrimination error and self-reported confidence of response. Using concepts and simple rules, these researchers have determined that fine and gross discrimination errors are the two ends of the error continuum. Fine discrimination errors are "close-in" nonexamples of correct concepts. They are incorrect responses that are almost correct. At the opposite end of the continuum are gross discrimination errors are "far-out" nonexamples. Dempsey and Driscoll (1993) state that these errors "suggest that the learners have failed to comprehend the material (p. 4).

In reference to a study by Chanond, Mory (1994) presented the resulting pattern of feedback study times relative to confidence certitude from lowest to highest: High Certitude/ Correct Responses, Low Certitude/Correct Responses, Low Certitude/Errors, and High Certitude/Errors. The question must be raised: How does the type of discrimination error made, combined with the degree of response certitude possessed by the learner, impact the amount of time spent on feedback?

Simply put, "discrepancy" is the amount of difference between the expected response verification by the learner and the actual response verification. Mory (1996)

states, “If learners receive verification of a correct answer when they are certain they were correct, there is no discrepancy” (p. 921). Conversely, a high level of discrepancy will be produced when learners discover that their answers were wrong while being confident that the answers were correct (Mory, 1996). It is discrepancy, therefore, that has direct impact on feedback study time. According to Kulhavy and Stock, “As discrepancy increases, feedback-processing time increases accordingly” (1989, p. 296).

Relevant Literature

Technological Advances

Technological advances of the late 20th century have had a tremendous impact on communication and, therefore, on educational processes as well. The development of the personal computer, with its resulting ripple effect of trailing technologies, was probably the single most important technogical event of the last two decades. The resulting additions to our lexicon include terms like *hardware*, *software*, *plug-and-play*, *email*, *online*, *dial-up*, *broadband*, *drivers*, the *Internet,* and the *Web*. As with any progressive technology and competition in the marketplace, personal computers have become more affordable and more accessible. Ease-of-use products and high-speed Internet access literally deliver information and data to the user instantaneously. This allows for a more easily delivered and accessible means of obtaining numerous types of information from a distance.

Distance Education

Distance education is not a current phenomenon. It actually has its origins in the development of the first correspondence course in 1840, when an Englishman invented a shorthand dictation method and the necessary distance education delivery system

(Matthews, 1999). In the early 1900s, correspondence education departments were established at the University of Chicago and the University of Queensland in Australia. The original and continuing purpose of distance education was not to challenge or change traditional higher education. Rather, it was to extend educational opportunities and to overcome the "inherent problems of scarcity and exclusivity" (Matthews, 1999, p. 2). Distance education deals directly with the problems of growth and physical space. Rather than offering seats and classroom spaces, universities can offer students the opportunity to learn (Matthews, 1999).

Moore and Kearsley (1996) provide a working definition of distance education:

> Distance education is planned learning that normally occurs in a different place from teaching and as a result requires special techniques of course design, special instructional techniques, special methods of communication by electronic and other technology, as well as special organizational and administrative arrangements (p. 2).

Distance education offers learning through a myriad of varied technologies, including, but not limited to, mail, email, faxes, radio, TV, VHS tapes, teleconferencing, satellite broadcasts, computer-based instruction (CBI), and Web-based instruction (WBI). Video-conferencing is pedagogically close to brick-and-mortar teaching. The only thing that would separate the teacher from the students would be space, distance, and any technical difficulties arising from the use of such technologies. The teacher is in one location, and learners are geographically separated from that instructor in a remote location. Further, through the continuing development of such technologies, time is also becoming increasingly less of a constraint to consider as greater connectivity and expanded networks become more commonplace.

A major paradigm shift is certainly occurring in the realm of distance education. Inherent in distance education is the aim to provide learning opportunities that are convenient for the learner rather than for institutions and instructors. Therefore, one could logically question what effect the laws of supply and demand have on learning delivery systems. In 1969, the Open University (OU) was founded in the United Kingdom with a mixed media approach to teaching. By 1995, OU offered classes in Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal, Ireland, and Spain (Matthews, 1999).

Historically, higher education in the United States may have been immune to fluctuations in the world's financial markets. Traditionally, instructors do not behave as vendors, and students do not behave as consumers who pay the bills. The onset of virtual education could change the supply and demand behaviors of suppliers and consumers of educational products. It is evident that in addition to the social "value-added" component of formal education (i.e., "finding oneself"), the reason for getting a college education is to enable one to obtain a job paying more than a minimal wage. With the rise in virtual education, colleges and universities are no longer the sole suppliers of formal education. Business, industry, and the military are moving to the forefront, not waiting for institutions of higher learning to teach potential and existing employees what they need to know (Schank, 2002).

While many traditional higher educational institutions still maintain the "youth camp" ambiance, the fact is that during the last decade the adult learner became the majority class of post-secondary student. Stallings (2002) states that three trends are emerging in education and training:

1. Knowledge (apart from information) will become a more explicitly measurable commodity.
2. The measurement of an organization's knowledge will become as important as its capitalization.
3. The competencies and capabilities of workers and managers will become more intensely measured (p. 5).

In light of a faltering economy and geo-political unrest, our global society and its high-tech, diverse economy is realigning its expectations to integrate existing fundamental values with emerging capabilities. Educational and training organizations, including the virtual university, must now focus on how graduates measure up in the workforce (Stallings, 2002).

Web-Based Instruction

Web-based Instruction is a product of the evolution of programmed instruction, distance education, and technology. Twenty years after the invention of the first teaching machine, B.F. Skinner reintroduced programmed instruction based on his behavoristic theory of learning (cited in Mory, 1996). This method of instruction involved presenting new material to learners in controlled sequences. They were able to move through the instruction at their own pace in a step-by-step fashion and were immediately presented an inserted question after each step in the sequence, the intent of which was to shape behavior and strengthen desired responses (Skinner, as cited in Mory, 1996).

The growing use of computers has given rise to multimedia presentations that include graphics, animations, simulations, and text in computer-based instruction. Unlike the linear presentations of early programmed instruction, computer-based instruction provided the learner with more opportunities to explore. In his 1997 article, Henke quotes Clark's 1996 definition of Web-Based Instruction/Web-Based Training (WBI/WBT) as: "Individualized instruction delivered over public or private computer

networks and displayed by a Web browser. WBT is not downloaded computer-based training (CBT), but rather on-demand training stored in a server and accessed across a network" (Henke, 1997, p. 1). WBI/WBT can be updated very rapidly, and access to training may be controlled more extensively and readily by the training provider (Henke, 1997).

The reason that any technology flourishes is because of standardized formats and ease of use. The same is true for the World Wide Web. The standard form of the uniform resource locator (URL) used throughout the world is the "hypertext transfer protocol" with hypertext markup languages (html) to facilitate programming. A URL address will open a home page in New Zealand as easily as in North Carolina, barring differences in connectivity speeds. Format standardization makes accessibility consistent and constant. In addition to standardized protocols and text, today's Web users have user-friendly access to full color graphics and photography, full motion color video, and high fidelity sound. "Is it any wonder that the Web is the fastest growing communication system in history?" (Crossman, 1997, p. 21).

The Internet is viewed as a viable educational tool as evidenced by its widespread usage. The National Center for Educational Statistics reported that in 2001, 99% of United States public schools had access to the Internet (National Center for Educational Statistics, 2002). In March 2002 press releases, Computer Industry Almanac, Inc. reported that the number of PCs-in-use surpassed 600 million units, while Internet users topped 530 million by the end of 2001. At the same year-end, there were 175 million PCs-in-use with 149 million Internet users in the United States. They further predict that

the number of worldwide Internet users will double to 1.12 billion by 2005, 48% of which would be wireless users (http://www.c-i-a.com/).

While the Web is not the solution to all educational problems, it can solve some problems that the traditional classroom delivery system cannot. It provides the impetus for educators and trainers to "push the envelope" in the 21st century. Institutional philosophy and budget constraints will impact the degree to which emerging technologies are used in any education/training forum. For example, it is the current philosophy of the Department of the Navy to offer educational and training opportunities to the Fleet, anytime and anywhere. The Naval Postgraduate School (NPS) in Monterey, California currently offers six masters degree programs and two certification programs via distance education. NPS serves as the portal for Navy e-learning (http://www.nps.navy.mil/dl/index.html).

Communication and Technology.

Basic to human nature and existence is communication between people. Most frequent in our daily lives is one-on-one, two-way communication between individuals. However, our lives are enriched by numerous forms of one-way communication for news and entertainment by such sources as by radio and television. Technological enhancements in the entertainment industry have leaped dramatically with portability. Consider the technological advancements that began with portable radios and the demands of the teenagers of the 1960s to be able to take their music with them wherever they went. Society has held witness to portable radios becoming smaller and cheaper, the rise of boom boxes, and emerging most recently, MP3 players. Consumers can choose between televisions that are the size of a watch face or covering a wall.

It is the opinion of this author that trends in the technology marketplace, which is driven by the supply and demand for business and entertainment technology, give rise to the availability of technology in educational settings. Because the area of teacher education is a natural recipient of technologies, it is a ripe and fertile field for integration of each technological advancement. In the traditional entertainment setting, communication is one-way and does not require any response from the consumer. However, that is not the case for basic human communication, nor is it within educational settings. Despite cutting-edge news and action-packed entertainment forums, we, as humans, require interaction. That interaction is feedback. In order for society to advance, two-way communication with feedback must occur in the daily lives of society's individual members. Feedback can be as simple as a look or the nod of a head or some form of communication by a professor online.

Communication in Online Learning.

The nature of the online environment is that instructors and students are separated by space and, frequently, time. During those occurrences when instructors and students are online at the same moment, communicating in "real time," *synchronous* communication occurs. However, typically instructors and learners are not on their computers concurrently, resulting in what is termed *asynchronous* communication. Usually, the instructor will post assignments and learners will post the required response by a specified deadline (Addesso, 2000).

One of the downsides of asynchronous communication features of online learning is the potential for learners to become isolated or feel detached. The instructional technique that instructors have to keep learners on task and "attached" to the class is

feedback. Lacking the nonverbal signals available in the traditional classroom, feedback is even more important in an asynchronous online environment. Brindle and Levesque (2000) report that many learners, females in particular, learn more readily when their personal experiences are acknowledged and validated. This validation serves as a springboard for subsequent learning. Learners in a traditional classroom discover early on whether the professor truly desires two-way communication, which, in turn, affects learner participation.

Creating a community of learners in distance education is different from establishing an educational environment (Hill, 1997). Online learners need appropriate feedback on performance more than learners in traditional settings, because learning online is complicated by the disconnect between the learner and electronic textual communication. The lack of a sufficient amount of relevant feedback is one of the most common sources of frustration and dissatisfaction for distance learners (Moore & Kearsley, 1996). "The creation of a virtual community will add to the support needed in a distance learning environment to move it toward becoming an environment for learning" (Hill, 1997, p. 78).

"Web-based learning environments use the resources of the Web to create a context in which learning is supported and fostered. The Web offers many unique characteristics and features for both educator and student. These attributes range from cost effectiveness from a university business perspective to convenience and flexibility of structure for the student" (Daughtery & Funke [Retrieved from the WWW June 28, 2002. Available at http://cade.athabascau.ca?vol13.1/daughrtery.html)].

Feedback and Instruction

Clariana (retrieved 12/19/2002) states, "Our physical and social environments are full of feedback, and we are wired to use this feedback, often automatically" (p. 1). Feedback is an elemental part of human communication and, as such, it is a vital part of the education process. The American Heritage Dictionary of the English Language (1976) broadly defines feedback as "any information about the result of a process" (p. 482). Because of the cause and effect association, humans come to understand activities and processes by both passive observation and active manipulation. In a social context, feedback is a response to our actions (Clariana, 2002). It can be conveyed as simply as a facial expression (such as a smile), or vocally expressed with a comment of, "Good job!" Effective feedback raises the educational process above a mere trial-and-error learning experience, and it makes the learning process more efficient by giving specific information about errors or misconceptions.

Gagné (1977) states that the single act of learning is a set of processes with a beginning and an end. Each phase in the processing of information is referred to as an *event of learning* (p. 51). These learning processes serve as the basis for information-processing learning theories and the ensuing information-processing model. Gagné depicts learning as a loop, beginning with stimulation from the external environment and ending with the final link in the loop, feedback. Feedback is the learning event that provides confirmation or negation that the purpose of learning has been accomplished (Gagné, 1977).

According to Gagné, Briggs, and Wager (1992), there is no single standard for phrasing or delivering feedback. Frequently, printed texts have correct answers

included in the back of the book. The function of feedback is to provide information about the degree of correctness of the learner's performance. However, when circumstances require that instruction be delivered via the Web, how do feedback requirements change? In Web-based courses, it remains the responsibility of the instructor to provide learners with feedback relative to their performance. However, in the electronic environment, how is the instructor to know how much "stroking" or instructional reinforcement students require? The ultimate goal of instruction is for students to achieve the goals and objectives of the course. How does feedback support the goals of any CBI/WBI course?

Kulhavy and Wager (1993) describe the historical overview of feedback during the 20th century as a triad. The points of the feedback triad are motivation, reinforcement, and information. First of all, the basic belief was that if you let the learners know how they are performing, it will increase future performance motivation. Second is the Law of Effect, formulated by Thorndike in 1913 and reformulated it into what is now called the Truncated Law of Effect in 1932. The "effect" of satisfying states remained as the primary mechanism on learning. "This is the parent concept of the reinforcement position developed by Skinner, and reinforcement in the operant setting is often said to follow the 'Empirical Law of Effect'" (Kulhavy & Wager, 1993, p. 5). Thirdly, one must consider the concept of feedback as information. The difference between the information point of the triad and the other two points lies in error response treatment. Information processing serves as the foundation for this point, because this model views learners as adaptable to the task at hand. For example, when a learner makes an error, information

feedback allows for correcting the error. It is a precept of information-processing models that learners are active participants in the learning process (Kulhavy & Wager, 1993).

In multimedia learning environments, interactivity is a critical design element, but it is only half of the interaction loop. Smith and Ragan (1993, p. 75) state, "Feedback is the instructional system's response to the learner's actions." Instructional or informational feedback is designed to provide learners with information about the quality of their responses, which may include correctness, accuracy, precision, timeliness, or efficiency of a response. Feedback may also inform learners how they compare to their own previous performances, or how their performances compare with others' (Smith & Ragan, 1993).

According to Alessi and Trollip (2001), pedagogical attributes of any well-designed multimedia program are critical to its success and should be evaluated with care. As a pedagogical issue, feedback in a CBI/WBI multimedia platform should always be constructive and related to the learner's response; should not be misleading or ambiguous, but rather be obvious to the learner how to respond to questions; and should not contain procedural ambiguity (Alessi & Trollip, 2001). For both intellectual skills and verbal information, feedback should be balanced by focusing on both successes and failures. When instruction is designed so that feedback is perceived as helpful information rather than as criticism, learners will use the information to improve their performance (Dick & Carey, 1996).

In a multimedia forum, interactivity is typically considered to be the interaction between the learner and the media such as the computer. Northrup (2001) cites several different definitions of *interactivity* for WBI, all of which agree that its purpose is

instructional or for task completion, social relationship building, or a mix of both. Northrup (2001) refers to Northrup and Rasmussen's classification of interaction as (1) learner to learner, (2) learner to instructor, (3) learner to instructional materials, and (4) learner to management [feedback]. Feedback as management is the instructional strategy that closes the communication loop on areas of both instructional content and social communication. However, there must be mutual coherence between the instructor and the learner that the communication loop is closed. What the learner perceives and the instructor assumes must be the same thing (Northrup, 2001).

Types of Feedback

In 1977, Kulhavy gave a generic definition of feedback as "any of the numerous procedures that are used to tell a learner if an instructional response is right or wrong" (Kulhavy, p. 211). He cited numerous studies supporting the view that telling learners whether or not their answers are correct increases the amount of material remembered on a later test (Kulhavy, 1977). If this point is accepted, then a resulting question would be, "What kind of feedback and in what detail is most effective and efficient?" Kulhavy posits the possibility that feedback could be a continuum ranging from simple "Yes-No" format to increasingly complex feedback. In theory, the feedback could be so complex that the process takes on the form of new instruction. Kulhavy went further to conclude that feedback following a wrong response probably has the greatest positive effect (Kulhavy, 1977).

In a Web-based environment, designers have a multitude of feedback options. Designers could choose to give the student a grade at the end of the lesson with no information about specific items. At the opposite end of the feedback continuum is an

item-by-item, elaborated, adaptive feedback response. Based on their review of literature, Smith and Ragan (1993) posit "some feedback is better than no feedback at all." Mason and Bruning (2002) point out that one of the advantages of technology-rich learning environments is the ability to give the learners instantaneous feedback on individual responses.

Roper (1977) examined feedback in computer assisted instruction (CAI) and stated that most feedback used in CAI falls into one of five categories:

1. No feedback.
2. 'Correct' or 'Wrong' or their cognates.
3. 'Correct' or 'Wrong' plus the correct answer.
4. 'Correct' or 'Wrong' plus the correct answer plus an explanation.
5. 'Correct' or 'Wrong' plus interactive teaching.

In the same study, Roper referred to the terms "knowledge of results" (KR) and "knowledge of correct response" (KCR) in which KR and KCR are referred to as the "two major categories of theory that attempt to explain their effect on learning – response strengthening theories and error-correcting theories" (1977).

Kulhavy and Stock (1989) reported the results of a research study where they examined feedback and learners' level of certainty of each response. They propose that feedback contains verification and elaboration. When feedback contains more than verification ("Yes-No" or "Right-Wrong"), then elaboration exists. Underlying the value of elaboration is the information-processing assumption that giving the learner more information will produce better performance, thus allowing higher information feedback load to facilitate the greater likelihood of error correction (Kulhavy & Stock, 1989).

Kulhavy and Stock (1989) developed a three-cycle model that served two purposes. First, it explained how feedback following an instructional response might be

viewed as fitting some type of Thorndike's "Law of Effect." They further posited that the confusion between reinforcement and feedback rests where the similarity of the sequence of events is similar. Secondly, the model depicted how the degree of elaboration fits into the feedback model.

It is Kulhavy and Stock's position that elaboration is the mechanism by which the elimination, substitution, and strengthening functions of feedback accomplish its essential purpose. Based on years of examining research studies, they classify three types of elaboration: task specific, instruction-based, and extra-instructional. The most common type of task specific elaboration is simply a restatement of the correct answer. Instruction-based elaboration gives the learner information derived from the specific lesson material. It may explain why a particular response is correct. Extra-instructional may provide new information to the learner to clarify its meaning including examples and analogies. They indicated that there are limited examples of this latter form of elaboration in research studies (Kulhavy and Stock, 1989). Later studies (Mory 1991, 1994) however, have examined the use of extra-instructional feedback.

Form and load are indices that can be extrapolated from task elaboration. The form index "refers to changes in stimulus structure between the instruction and the feedback message" (Kulhavy & Stock, 1989, p. 286). Load is the amount of information that is given to the learner in the feedback response. Minimal feedback load would be a simple "yes/no." Load increases along a continuum to the point that an explanation item is added to the feedback item (Kulhavy & Stock, 1989).

With the development of the definition of the feedback indices, Kulhavy and Stock are able to partition the content of feedback and present the formula:

Feedback = Verification + Elaboration (Type, Form, Load)

Given the simplified shorthand notation for feedback as (*f*), the verification component as (f_v), and any added elaboration component (f_i), an expression can be constructed to state the effects that feedback may have on a learner:

$$f = (f_v + f_i)$$

This conceptual relationship provides a framework for comparing the results of research on feedback elaboration (Kulhavy & Stock, 1989).

In the literature review for their 1993 study, Dempsey, Litchfield, and Driscoll found that *knowledge of correct response* (KCR) was superior to *knowledge-of-results* (KR). Additionally they state that either type of feedback in a computer-based environment is better than no feedback (1993). In the study, they compared four types of KCR including: (a) knowledge of correct response only (KCR), (b) knowledge of correct response and a forced correct response (KCR + Forced CR), (c) knowledge of correct response and anticipated wrong answer remediation (KCR +AWA), and (d) knowledge of correct response and a second try to respond to the item (KCR + Second Try). They concluded that the simpler forms of KCR corrective feedback are just as effective as the more complex forms. They further conclude that while simple KCR feedback is just as effective as complex feedback, it is much more cost effective for the developer. Since developers have the responsibility of allocating resources, including time, to each element of a design project, the resulting product must have value greater that the cost of the resources required producing that final product.

Mason and Bruning (2002) identify eight commonly used levels of feedback:

1. No-feedback: This minimal level of feedback simply states a proportional level of correct responses.

2. Knowledge-of-response: This level of feedback provides verification but no elaboration.

3. Answer-until-correct: Containing no elaboration, this level of feedback requires that the learner remain on each test item until the correct answer is selected.

4. Knowledge-of-correct- response: While providing no elaboration, this feedback provides individual items verification and provides the learner with the correct answer.

5. Topic-contingent: This feedback gives general elaborative information while it gives item verification.

6. Response-contingent: This feedback gives both verification and item-specific elaboration. The learner is provided with elaboration as to why their answer is incorrect and why the correct answer is correct.

7. Bug-related: Address specific errors. "Bug libraries" are rules, which identify and correct common errors. The correct response is not provided, but it provides information to make self-correction possible.

8. Attribute-isolation: Focuses learners on key components of the knowledge concept to focus learners on key components of the concept.

Clariana (2002) presents three categories of feedback to include explanatory, directive, and monitoring feedback. Explanatory feedback provides the learner with additional information as to the correctness/incorrectness of the response. In a computer-based lesson, addition remedial screens could serve as new instruction. Directive feedback is designed to help the learner determine the correct response and may include prompts, cues, or hints. Answer-until-correct is a common type of directive feedback. Monitoring feedback is also referred to as advisement and is a meta-level feedback. It allows the learner to know how he or she is doing overall. For example, the screen may show the learner on-going lesson scores, links of instructional branching, and end-of-

lesson/unit scores. Monitoring feedback's primary role is that of affecting continuing motivation rather than specific error correction (Clariana, 2002).

Learner task responses have taken a quantum leap from slate chalkboards to computer keyboards. The learner who uses a keyboard has a much different idea of what a mouse is compared to the learner who used a chalkboard slate. When learners offer a response to a task, they philosophically require knowledge as to the quality of that response. The knowledge of that response is feedback. It has been the responsibility of educational researchers over time to determine what the most effective and efficient form of feedback is.

It is Clariana's position that KCR feedback is appropriate for procedural learning and automaticity drills. He further posits that KCR feedback is preferred over multiple-try feedback (MTF) for low-prior knowledge learners. MTF could be useless, frustrating, and likely counterproductive for these learners. When low-prior knowledge learners must respond until they find the correct answer, they tend to scramble the few existing correct associations (2002).

Response Certitude

While the operant psychology position is that feedback operates to reinforce correct answers, and the information processing position is that feedback primarily operates to correct error responses, the role of feedback may be much more complex than either or both of these. For either of these positions to be correct, a response must be judged absolutely correct or absolutely incorrect. Kulhavy et al. (1976) posit that embedded in the learner's response mechanism is the concept of response confidence. Learners "create a hierarchy of confidence in the correctness of possible choices and then

make their response selection based on what they believe to be the most probable right answer" (Kulhavy et al., 1976, p. 522). If feedback operates to correct error responses, how does the learner react to that feedback in light of the invested confidence in a response? Kulhavy and Stock (1989) present the term *response certitude* and define it as a metacognitive knowledge estimate.

In their 1989 research, Kulhavy and Stock suggest that the hub of their theory is the response certitude variable. They believe that the level of confidence and response durability are positively related. Durability refers to how likely a learner will be to remember a response at a later time. It is their view that the degree to which a learner feels his response is correct has much to do with his reaction to subsequent feedback and to performance in a later testing situation. In a study that predates the 1989 Kulhavy and Stock study, Kulhavy et al. (1979) investigated feedback and content review in programmed instruction. Citing the 1971 study by Anderson, Kulhavy and Andre, Kulhavy et al. state, "Students are likely to remember more about an instructional response if they receive feedback after making it" (1979, p. 91). Their ensuing model was designed to test response confidence in a programmed instruction environment. These authors state that the degree of confidence that the learner has in a particular response determines what benefits he will receive from seeing feedback after his response. Kulhavy et al. indicate that the learner's reaction to feedback is a function of the dual nature of initial confidence of response and the correctness of the response.

Kulhavy's research group present a hypothesized relationship between feedback, confidence in the correctness of the response, and post-response behavior. The authors state, "This model assumes that confidence in an answer is at least as important as its

correctness in determining how feedback is used" (Kulhavy, et al., 1979, p. 91). The leftmost branch of the Kulhavy et al. (1979) three-branch model represents a correct answer with high confidence. The authors believe that feedback will receive only cursory attention. When the learner is sure of the correctness of the response, he will briefly attend the feedback only to validate the decision and move on to the task at hand. The resulting outcome is quite different when the initial confidence in the response is high, but the produced response is incorrect. This learner is likely to spend considerable time studying feedback because he is unsure why their answer is incorrect and seek to correct it.

The two remaining branches of the model address the situation when confidence is low. Low confidence is usually representative of lack of understanding of the lesson material. When considering feedback study time, Kulhavy and his colleagues (1979) predict that, when confidence is low, the correctness of the answer may be irrelevant. Total amount of time the learner spends reviewing feedback differs little for right and wrong responses. The model indicates when the answer is either correct or wrong, no matter the level of confidence, the learner will rescan the text to find the source of the error to be able to correct it.

The results of this and other studies (Kulhavy & Stock, 1989; Dempsey & Driscoll, 1993; Mory, 1994) suggest the powerful effects of feedback in modifying both study and test behaviors. Citing Kulhavy (1977), the authors conclude that the combination of increased comprehension and the corrective effect of feedback may act to reduce the likelihood of errors in judgment. Their feedback study times findings closely approximated the events of their model. When confidence is low, feedback study time is

approximately equal for both correct and incorrect responses. When confidence is high, information more than knowledge of correct response is irrelevant to the learner. Only cursory attention is given to detail. It was determined that high confidence with wrong answers increase feedback study time to a maximum when feedback is provided (Kulhavy et al., 1979).

Table 1. displays the successive steps within Kulhavy and Stock's (1989) standard feedback paradigm.

Table 1. Kulhavy and Stock's Feedback Paradigm

INSTRUCTIONAL INPUT OUTPUT		LEARNER		RESPONSE
CYCLE I				
Instructional task demand	(*A*) →	*a*	→	*R1*
CYCLE II				
Feedback	(*F*) →	*b*	→	*R2*
CYCLE III				
Criterion task demand	(*A*) →	*a*	→	R3

In Cycle I, the learner is presented with an instructional task demand (*A*) which is perceived and processed as (*a*) and the (*R1*) initial instructional response is produced. In Cycle II, feedback (*F*) is presented to the learner. Its perceived form (*b)* is processed to produce the post feedback response *R2*. In Cycle III the original task demand (*A*) is re-presented to the learner as a criterion item. This item is processed as (*a*) and leads to (*R3*), the terminal response (Kulhavy & Stock, 1989).

The Kulhavy and Stock model assumes that learners assign some degree of certainty to each instructional response. While their judgments are not perfect, learners are able to predict whether they possess a certain amount of knowledge. Kulhavy and Stock suggest that the learner's degree of expectation about response correctness impacts behavior at feedback and on a later test. They believe that estimates of certitude and the *durability* of responses are positively related. The definition of *durability* they present is "the likelihood that an instructional response will be available for the learner's use at some later point in time" (Kulhavy & Stock, 1989, p. 296). Response certitude, therefore, serves as a type of comprehension index, amplifying the learner's ability to relate a present task to a prior knowledge base. A discrepancy exists when there is a measure of the interaction between verification and the initial response certitude (Kulhavy & Stock, 1989). "Discrepancy, then, is an index of the degree of match between internal and external models of knowledge" (Swindell, 1992, p. 30). Kulhavy & Stock (1989) support the premise that the discrepancy value is the determinant of subsequent learner behavior.

Basic to information processing theories is the concept of learners using informative feedback to correct errors. With the possibility of instructional responses

being either correct or incorrect, and learner response certitude ranging along a continuum from low to high, what are the possible impacts on learner behavior? Kulhavy and Stock (1989) propose that as discrepancy values increase, feedback processing time should increase proportionately. For example, if a learner reports high certitude, but finds his answer incorrect, "the successful feedback cycle must eliminate the error response, substitute the correct, and strengthen the new response to the extent necessary for it to appear on the posttest" (Kulhavy & Stock, 1989, p. 297). High certitude errors will post the highest discrepancy values, therefore requiring the longest feedback processing time.

On the other end of the continuum are the high certitude correct responses. In this scenario, discrepancy values are at a minimum. It should be evident that correct responses have a solid foundation in a prior knowledge base. Accordingly, feedback serves to maintain this knowledge base with a high probability that the same correct response will endure through the posttest. Innate efficiency would question the need for the learner to spend time studying feedback when a sufficient knowledge base exists (Kulhavy & Stock, 1989).

When the learner cannot draw upon appropriate reference points in a prior knowledge base, he will assign a low response certitude estimate for the task at hand. For the purpose of feedback processing time, it is irrelevant whether the response was correct or not. If the learner has difficulty comprehending the task demand or performance criterion, the feedback message becomes quasi-instructional for both correct and incorrect responses. The learner has no basis for why his answer was correct or why it was incorrect. Kulhavy and Stock (1989) suggest that the learner will use the feedback as

instructional, and the time spent reviewing the feedback will increase with the lack of certitude, regardless of the correctness of the response.

Learning Types

According to Gagné's interpretation of information processing, multiple transformations take place in the brain for learning to occur. The first transformation occurs when an initial event is sensed such as by seeing or hearing. The learner must register or attend to the event to begin the process. Secondly, the information derived from this event must be temporarily stored in the short-term or working memory. A third kind of processing occurs when the information is processed and stored in long-term memory. It is when a learner uses a fourth kind of process that the information is retrieved from long-term memory. The retrieval of information leads to observation of the learner's performance. What comes to light are called types of *learned capabilities.* "Once these varieties of learning outcome have been identified, an account can be given of the *conditions* that govern the occurrence of learning and remembering" (Gagné, 1985, p. 15).

Gagné identifies five varieties of learned capabilities including intellectual skills, verbal information, cognitive strategies, motor skills, and attitudes. Intellectual skills are a learning capability that is evidenced by "knowing how" or *procedural knowledge* (Gagné, 1985, p. 15). Procedural knowledge contrasts with learning that something exists or has certain properties. According to Gagné, Briggs, and Wager (1992), this type of learning is verbal information. These authors give the example of identifying a sonnet by its rhyme pattern as an intellectual skill. However, learning the lines of the sonnet is an example of verbal information.

Concept Learning

Within the intellectual skills capabilities is the subcategory of concept learning. Smith and Ragan (1993) refer to Merrill and Tennyson's 1977 definition of a concept "as 'a set of specific objects, symbols, or events which are grouped together on the basis of shared characteristics and which can be referenced by a particular name or symbol'." Two cognitive processes are required for concept learning: generalization and discrimination. Upon first exposure to a concept, the learner must learn to *generalize* beyond that single event to be able to identity a member of the same category. As one learns, he must be able to *discriminate* between examples of members of a particular set, as well as non-members of the same set (Smith & Ragan, 1993). Basic to Gagné's conditions of learning is the precept that discriminations are the foundation, or prerequisites, for concept learning. As people progress through their lives, they must learn new discriminations of faces, objects, and symbols in novel situations.

Referring to Tennyson, Cocchiarella, and Merrill's position on concept learning, Litchfield, Driscoll and Dempsey (1990) state those interrogatory examples of concepts should be presented systematically in an easy to difficult arrangement. "Examples and matched nonexamples should be presented within a problem domain to enhance discrimination of critical concept attributes" (p. 35). In order to promote generalization, divergent examples should be presented to the learners to enhance recognition of variable attributes. Because of the lack of theoretically- or empirically-based guidelines in computer-based instruction, their study was conducted to address the need for determining difficulty level of examples and for sequencing the examples in the most effective way (Litchfield et al., 1990).

The first purpose of the 1990 study was to compare adaptive and all-inclusive (linear) sequence examples. The second purpose was to examine at the effectiveness of the lesson using both types of example sequencing. Within the confines of the software and design elements, computers have the capability of providing the learner with adaptive example sequences, meaning that sequences depended in the learner's prior performance. Additionally, data collected during the computer-based lesson are easily accessible and can be analyzed to determine instructional efficiency (Litchfield et al., 1990).

The researchers found that the learners in the inclusive group did slightly better on the retention test than those in the adaptive group. They also found, however, that the adaptive group performed better overall on the examples with difficulty levels rated by generalization formulae than learners who studied examples with difficulty level rated by subject matter experts. It is important to note that while the differences in the treatment groups scores was not significant, the learners in the adaptive group spent less total time on the computer-based assignment than did the inclusive learners. While there were no major differences between the groups as a function of difficulty, the data indicated that the number of examples seen by the adaptive group was considerably less. The fact that the adaptive learners in the computer-based lesson required fewer examples and spent less time on task to fulfill lesson criterion speaks to efficiency. It must be pointed out that the reason the inclusive group scored slightly higher on the retention test could be because they spent more time with more examples (Litchfield et al., 1990).

One must consider possible "trade-offs" between instructional efficiency and effectiveness. In the Litchfield et al. study, the researchers found that the difference in retention tests scores was not significant while the time-on-task was significantly

different. It should seem logical that designers would choose formats in which there is the least amount of "trade-off" between efficiency and effectiveness. In this case, the computer-based lesson proved more instructionally efficient with minor impact on effectiveness. The implication is clear that efficiencies inherent in computer-based instruction pave the way for encroaching technologies and increasing development of Web-based instruction.

In 1993, Dempsey et al. report the results of a study that was conducted to examine four types of knowledge-of-correct response (KCR) feedback. They examined the result of fine and gross discrimination errors on retention tests. Additionally, they questioned whether either type of error would increase feedback study- time when learners are confronted with corrective feedback. The format for this study was a computer-based biology lesson. Fourteen days after the computer-based instruction, the learners were given a paper-based, domain-referenced retention test.

As the learners worked through the lesson, they were exposed to four immediate corrective feedback conditions:

(1) Knowledge of correct response only
(KRC)
(2) Knowledge of correct response and forced correct response
(KCR + Forced CR)
(3) Knowledge of correct response and anticipated wrong answer remediation
(KCR + AWA)
(4) Knowledge of correct response and a second try to respond to the item
(KCR + Second Try)

Feedback study time was defined as elapsed time between the presentation of the response-contingent feedback and the learner pressing appropriate computer keys, thus advancing him to the next item. The computer collected feedback study time for each question (Dempsey et al., 1993).

To measure feedback efficiency Dempsey et al. used a technique somewhat similar in terminology and methodology to one used by Kulhavy and his colleagues in 1985. For the 1993 study, feedback efficiency was calculated "by dividing the correct retention percentage score by the square root of feedback study time" (Dempsey, et al., 1993, p. 310).

According to Gagné, *generalizability* is the characteristic of concept learning that distinguishes it from other types of capabilities. When learners possess this capability, they should be able to generalize the concept in different stimulus situations that did not have a part in the original learning. *"The effect of concept learning is to free the individual from control by specific stimuli*" (Gagné, 1985, p. 105).

Dempsey et al. (1993) use Markle and Tiemann's 1970 definition of fine discrimination errors as those errors that are related to close-in nonexamples of concepts or rules. Gross discrimination errors, conversely, are those errors that are related to far-out nonexamples. Learners overgeneralize when they classify a noninstance as an example of a concept. They undergeneralize when they classify examples of concepts as nonexamples. Learners form misconceptions when they combine overgeneralization and undergeneralization errors. Based on the results of this study, the authors raise the suspicion that learners making fine discrimination errors understand the critical attributes of the concept, but they overgeneralize it to include variable attributes. Because learners who make gross discrimination errors do not comprehend the critical variables of the concept, they are not able to build a foundation to support further successful exploration of the topic (Dempsey et al., 1993).

Dempsey's research group found that there were no significant differences on the retention test as a result of feedback type alone. The results of their study show that simple KCR feedback is just as effective more complex types feedback. Because of the increase in resources required designing, delivering and learning from complex feedback forms in a computer-based environment, the results of this study support the efficiency of simple KCR feedback for the designers and learners (Dempsey et al., 1993).

These researchers also state that isolating fine discrimination errors may indicate how well learners accomplish concept and rule learning. They further suggest that fine discrimination errors may predict retention test performance. One would expect that learners who make fewer fine discrimination errors while learning rules and concepts will be better prepared to classify novel examples in the future. Based on their research, Dempsey's research group conclude that learners spend much more time studying feedback when they made fine discrimination errors.

In a new line of research using a computer-based lesson of defined concepts and verbal formation tasks, Mory (1994) compared the effects of adaptive and non-adaptive feedback on two different types of learning tasks. Student performance, feedback-study time, and lesson efficiency were the variables by which the feedback effects were measured. While designers must take cost effectiveness into account, theoretically the type and amount of instructional feedback is limited only by time and creativity within a computer-based delivery system. The purpose of research is to determine what types of feedback are the most effective in that particular environment. The Mory (1994) study used a non-adaptive feedback treatment compared with a response-certitude adaptive feedback treatment. The non-adaptive treatment did not require the learners to supply

their degree of certainty relative to their responses. All of the subjects in the non-adaptive group received the same type of feedback. The treatment given to the response-certitude feedback subjects received feedback based on the combined assessment of response correctness and their level of response certitude.

While the independent variable in Mory's study was the type of feedback presentation forms (non-adaptive and response certitude adaptive), the dependent variables were performance on a retention test, feedback-study times, and efficiency. Mory used Kulhavy and Stock's categorizations of feedback: Task Specific, Instruction-Based, and Extra-Instructional feedback elaborations. The feedback given to the non-adaptive treatment group was the same for both correct and incorrect responses. These learners received Task-Specific feedback that included knowledge of the correct answer and Instruction-Based feedback to include relevant lesson information. However, the learners in the response-certitude adaptive feedback group received prescribed feedback based upon their level of certainty in combination with correct or wrong answer choices. The feedback treatment was additive, and various combinations of Task-Specific, Instruction-Based, and Extra-Instructional feedback elaborations were administered according to a combined assessment of student's answer choice and response certitude level.

Mory presented three hypotheses. First, she hypothesized that the response-certitude adaptive group would perform better than the non-adaptive group for verbal information tasks and that there would be little difference in performance between the two groups for intellectual skills tasks. The second hypothesis addressed the issue of feedback-study time. Because the instructional delivery system was computer-based, the

feedback-study time was measured in seconds as the amount of time the learner spent studying feedback within the context of the lesson (Mory, 1994). Shimmel (1988) suggests that learners, who do not labor at comprehending lesson material, acquire only superficial knowledge and have more difficulty recalling the information and later applying the knowledge to new situations. Mory's (1994) position was that the type of learning involved and the learner's degree of certainty combined with the correctness of the individual responses directly affect feedback-study time.

Mory's third hypothesis focuses on feedback and lesson efficiencies. She expected that feedback would be more efficient for the response-certitude adaptive feedback treatment learners than the non-adaptive treatment learners. She further expected that overall lesson efficiency would be somewhat equal for both treatment groups (Mory, 1994).

When a lesson is designed for an absolute correct or incorrect response, learner responses can be just that, correct or incorrect. The influence on feedback-study time is affected by the degree of learner's certainty about responses. Learners can be either correct or incorrect after posting a high or low level of response certitude. While Mory predicted that the response certitude adaptive group would perform better than the nonadaptive group with verbal information tasks, she did not find this to be the case. Based on the analysis of the results, she states that she did not find significant difference between the two groups. However, the analysis of the results supported her hypothesis for concept item performance in that there was no significant difference between adaptive and non-adaptive treatment groups (Mory, 1994).

To analyze feedback-study time, Mory used the Kulhavy and Stock definition of *discrepancy* as the difference between the answer correctness and the learner's level of certainty. Mory found that mean feedback-study times were much higher for verbal information than for concept items. When attending verbal information tasks, learners with High Confidence/Correct responses displayed the lowest feedback-study time. Learners who reported Low Confidence in their responses spent the highest amount of study time. Mory further discovered that, for concept items, the lowest feedback-study time was reported by learners with High Certitude/Correct responses. Because High Certitude/Error feedback-study times were significantly higher than Low Certitude responses, one could question whether these results arise from fine discrimination errors. This has implications for identifying the most efficient feedback to give when taking into account response certainty combined with answer correctness. In terms of overall lesson efficiency, Mory concluded that the adaptive lesson was not more efficient than the non-adaptive (1994).

Potential Contributions and Limitations of the Study

"Dot coms" have been infiltrated into global society at the speed of the Internet. Practically every advertisement in print and televised media incorporates the advertiser's Web site address in their marketing plan. As we attempt to assess student performance in a Web-based environment, the first thing we must take into consideration is how much technology has advanced since Mory's 1991 study. That fact being established, we must take into consideration how attitudes have changed about technology and its impact on educational opportunities in the most recent of times.

"Time is money" is a catch phrase of American business that has become engrained in all aspects of society, including education. Because of budget constraints, educational institutions are mandated to look for the most efficient delivery systems at their disposal. While Web-based instruction is not intended to entirely replace programs, this delivery system may prove beneficial in supplement to existing programs. Improving lesson efficiency in a Web-based learning environment is a valuable asset for both student and instructor.

The cognitive learning theory embraced by Gagné for the development of his *conditions of learning* is known as "information-processing theory." Information-processing theory uses a computer as a metaphor for human thought. Information is seen as being transformed or processed as it moves through the human system (Gagné & Medsker, 1996). The information-processing model is the learning theory that serves as the backbone for this study.

This study also corresponds to the tenets found within distance educational theory, which is used to describe the pedagogical relationships that exist in a distance educational environment. Moore (cited in Jung (2001) defines transactional distance theory as "the family of instructional methods in which the teaching behaviors are executed apart from the learning behaviors, including those that in contiguous teaching that would be performed in the learner's presence, so that communication between the teacher and the learner must be facilitated by print, electronic, mechanical, or other devices" (p. 526).

The conceptual framework for pedagogical features of Web-based instruction presented by Jung depicts three variables: structural features in WBI as a teaching

variable, dialogue in WBI as a communication variable, and learner autonomy as a learning variable (Jung, 2001). While it is not the purpose of this study to test the distance education model described by Jung, it must be noted that the current study does meet the requirements of the three variables of Jung's conceptual framework. The presentation of the lesson material in tutorial format in this study would qualify as the teaching variable. Feedback would act as the communication variable. The amount of time a learner chooses to spend studying feedback is the exercise of learner autonomy. Thus, the current study is supported by current distance learning principles.

METHODS

Research Design

Research Questions

The research questions in this study centered around the effects of certitude level on feedback study time, the relationship between response certitude level and discrimination error in concept learning, and the effects of feedback versus overall lesson efficiency. The main research questions were: (1) When comparing adaptive to nonadaptive treatments, are there any differences in improvement between pre- and posttests? (2) Do high certitude errors result in greater feedback study time than low certitude errors? (3) For verbal information feedback study time, will cases of high certitude/correct responses be less because these learners need only verification for correct answers? (4) Will feedback study times in concept learning tasks for high certitude/correct responses be less because these learners need only verification for correct answers? (5) Will feedback study times for verbal information questions be highest for both high certitude/wrong and low certitude/wrong instances? (6) Will

feedback study time for concept questions be highest for both high certitude/wrong and low certitude/wrong instances? (7) In concept learning, is more time spent on feedback after the learner makes a fine discrimination error rather than a gross discrimination error? (8) When considering the relationship between certitude level and discrimination error type in concept learning, do high certitude errors tend to correlate with fine discrimination errors? (9) Is feedback efficiency greater within the nonadaptive group than the adaptive group? (10) Are overall lesson efficiency results for the nonadaptive group greater than the adaptive group?

This study represents a partial replication of a 1991 study conducted by Mory. The purpose of her study was to compare the effects of adaptive and non-adaptive feedback treatments in a computer-based instructional environment. Utilizing a computer-based delivery system, the two treatments were designed to teach verbal information and defined concepts, a type of intellectual skill, both of which are part of Gagné's nine learning capabilities. In a 1994 description of the study, Mory stated, "The treatment presented verbal information and intellectual skills tasks using a computer-based delivery system to determine feedback's effects on student performance, feedback study time, and lesson efficiency" (p. 265-266). In her study, undergraduate introductory educational psychology students were randomly assigned to one of the two treatment groups. The amount and variety of adaptive feedback treatment used in the adaptive group was based on a combination of learner's response certitude level and the correctness of response on each question within the lesson. The non-adaptive treatment did not require the learner to give any response certitude judgments and did not provide

variation in the feedback. Consequently, students in the non-adaptive treatment group were presented the same level of feedback throughout.

Mory (1991) hypothesized that the response-certitude adaptive group would perform better than the non-adaptive group on verbal information tasks, but may not perform any better than the non-adaptive groups on intellectual skills tasks. Another hypothesis addressed feedback study time, with the expectation that students' time spent studying feedback after either a Low Certitude response, regardless of answer correctness, and High Certitude errors . Correspondingly, feedback study time should be the lowest for High Certitude/Corrects because the learner seeks only verification of the correct response. Mory also considered the fine and gross discrimination error types associated with concept learning tasks and explored whether any correlation exists between effects of discrimination error type and certitude level on the amount of time students spent studying feedback.

Her final hypothesis was concerned with feedback efficiency and overall lesson efficiency. Operationally defining feedback efficiency as a result of dividing the total number of correct posttest answers by the total amount of time spent studying feedback, Mory hypothesized that the response certitude adaptive feedback treatment should be more efficient than the non-adaptive treatment. She further suggested that, when considering overall lesson efficiency measured by total number of correct posttest answers divided by total lesson time, the two treatments would likely be equal. That is, the adaptive treatment would be no more efficient than the non-adaptive presentation form in terms of overall efficiency of the lesson to correct answers.

Independent Variables

For the purposes of this study in a Web-based environment, there were three independent variables identified. They include (1) the form of feedback presentation (adaptive versus non-adaptive), (2) the learners' level of response certitude (high versus low), and (3) the type of discrimination error (fine versus gross). According to Mory (1994), "A major feature of the computer is its ability to elicit responses and provide elaborative or adaptive feedback" (p. 263). This hallmark interactive capability holds true for Web-based lessons as well. According to Weston and Barker (2001), the Web affords the designer the capability to present a multitude of multimedia elements within a lesson, as well as give programmed feedback based on user-entered responses.

In consideration of the rapid progression of technology since the Mory (1991) study, this study will be examining feedback's effect on learning within a Web-based environment to determine whether similar findings might apply. Web-based instruction is made possible by the wide accessibility of the Internet and the World Wide Web (Weston & Barker, 2001). According to Ritchie and Hoffman (1997), instruction is a purposeful interaction intended to increase the learner's knowledge or skills in specific, predetermined ways. Within the context of this definition, it must be noted that simply publishing a page on the World Wide Web, even one containing hyperlinks to other digital resources, does not constitute instruction. Dick and Reiser, (as cited Ritchie & Hoffman, 1997) identify and define seven common elements typically included in instructional sequencing: (1) motivating the learner, (2) specifying what is to be learned, (3) prompting recall and applying previous knowledge, (4) providing new information,

(5) offering guidance and feedback, (6) testing comprehension, and (7) supplying remediation or enrichment.

Dependent Variables

There were three dependent variables used in this study. The first dependent variable was score improvements from pretest to posttest. Improvement scores were calculated as the percentage of improvement a student made from the pretest to the posttest. The choice to use improvement scores, as opposed to direct test scores, was made due to the nature of the type of learning being examined in each. Typically, pre- to posttest comparisons employ the actual test scores, because items used in the pretest are identical to (or a re-presentation of) items used in a posttest. However, in testing students' ability to successfully classify concepts, new examples of concepts must be used, not simply repeated examples. Had the actual test scores been compared, then pre- to posttest results would be based upon the assumption that the pre- to posttest items were identical. The use of identical questions on the two tests would be an appropriate measure of "rote" or verbal information learning, but would not determine whether students could classify new instances of examples – the key element in concept acquisition learning. While the question form and type of task remained identical, both the pretest and posttest consisted of unique (new) examples of Gagné's nine learning capabilities to identify.

A second variable, feedback study time, was measured to determine effects of varying certitude levels, answer correctness, and feedback load (the amount of information included in a feedback message). Prior research (Mory, 1991; 1994) suggests that the amount of time that students expend studying feedback not only

depends upon the amount of information presented in the feedback, but also on a combination of certitude level and answer correctness (Kulhavy, 1977; Kulhavy & Stock, 1989).

The remaining dependent variable studied was efficiency, which was measured in terms of both feedback efficiency and overall lesson efficiency. Feedback efficiency was measured by dividing the total number of correct posttest answers by the total amount of time spent studying feedback. Lesson efficiency was calculated by dividing the number of correct answers on the posttest by the total time spent in the lesson. While a treatment involving adaptive feedback based upon a combination of answer correctness and certitude might result in a smaller expenditure of feedback time to correct answers, this type of adaptive feedback requires that students report a certitude level after each question they answer. This repeated self-reporting adds considerable time to what the student must complete to finish the overall lesson. Although feedback adaptations might result in more effective feedback in terms of feedback study time alone, the addition of these self-report questions would increase the overall lesson time, thus decreasing the lesson's overall efficiency.

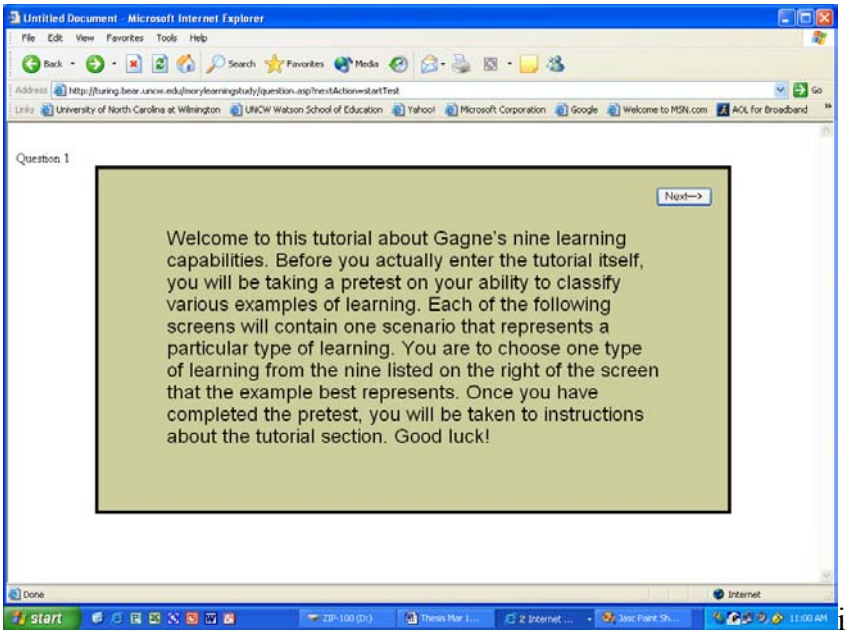
Materials

As a partial replication of previous research, the instructional material used in this study was the same as that designed by Mory (1991) and originated by S. U. Wager (1983) as a CBI lesson. With assistance from Dr. Ronald Vetter, the Chairman of the Computer Science department at UNCW, and Mitchell Waters, an advanced-level computer science student working under Dr. Vetter, the original CBI lesson material was adapted for Web-based delivery in the current study. Gagné's conditions of learning

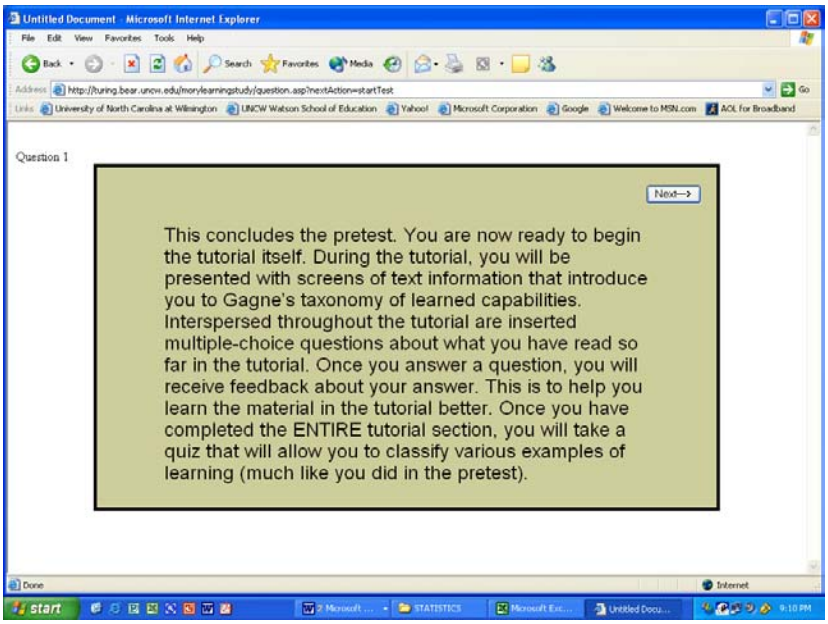
form the basis of the instructional material for this study, as represented in Gagné's (1985) textbook on the topic. The lesson was tutorial and linear in nature. As Web-based instruction, all of the lesson materials were in an electronic format, eliminating the necessity of paper copies.

Several CBI authoring programs will allow instruction and feedback to be converted to a format offered via the Web. However, the use of the Web affords the inclusion of dynamic database linking, thus offering a broader range of authoring possibilities. Mory's (1991) original CBI lesson was created using HyperCard authoring system. Similar CBI authoring tools currently in use include Macromedia Authorware and Click2Learn's Toolbook. To provide ease in future updates and dissemination, this version of the current Web-based tutorial utilized active server page (ASP) coding that drew information from and send data to separate database files. In recreating the original CBI for the Web environment, each screen of the text, each question, answer, and its associated feedback was entered into a specially designed Microsoft Access relational database. The Web instruction used active server pages (ASP) coded in Visual Basic to call up each sequence of instruction needed. Thus, the database information could be called up dynamically, a feature that was particularly important for the generation of adaptive feedback. The same Access database file was used as a data collection storage area for individual testing episodes, recording student ID, time spent on feedback screens, total lesson time, scores for inserted questions, and posttest scores.

As the students entered each portion of the tutorial, they received an informational welcome screen (see Figure 1a. and 1b.) that explained what they would encounter in that section.



a.



b.

Figure 1. a.) Pretest welcome screen.
b.) Tutorial welcome screen.

Following the beginning welcome screen, the participants were given a pretest. Pretest questions were presented one question per screen for a total of 30 questions. All 30 questions were based on classifying examples of defined concepts. None of the participants received inserted certitude questions or any type of feedback during the pretest. Pretests were identical in both the adaptive and nonadaptive versions of the tutorial. The design, question stem, and nine answer choices were based on Gagné's nine learning capabilities. Students had to classify an example of learning into one of the nine category types. Figure 2. presents an example pretest question screen.

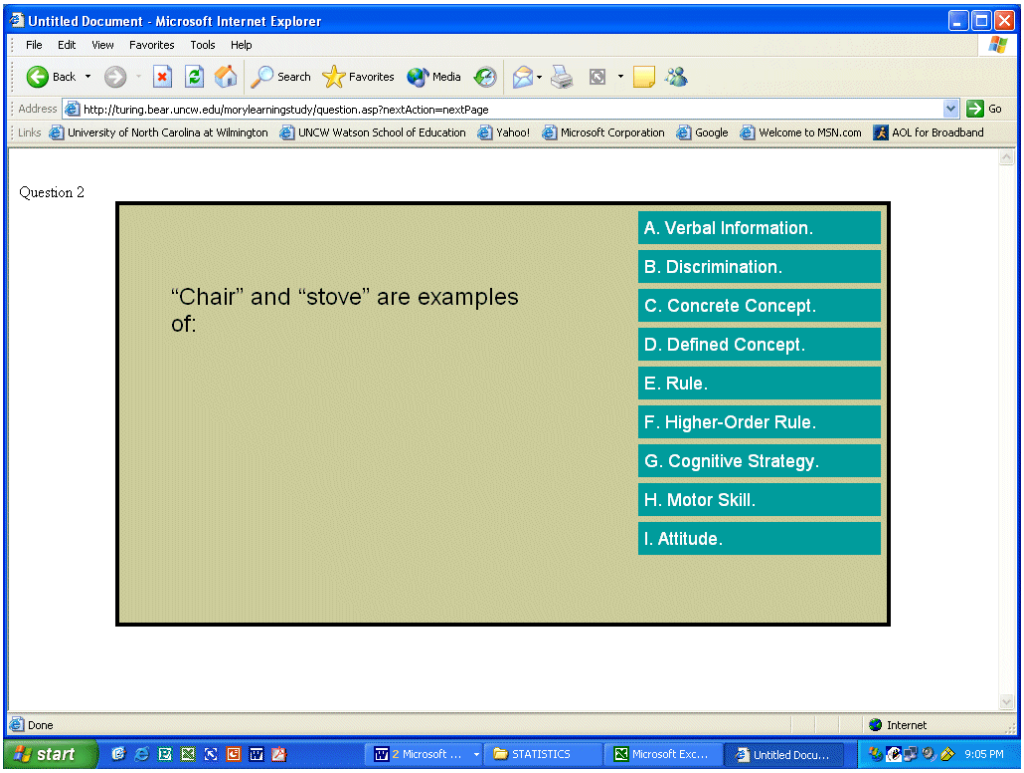
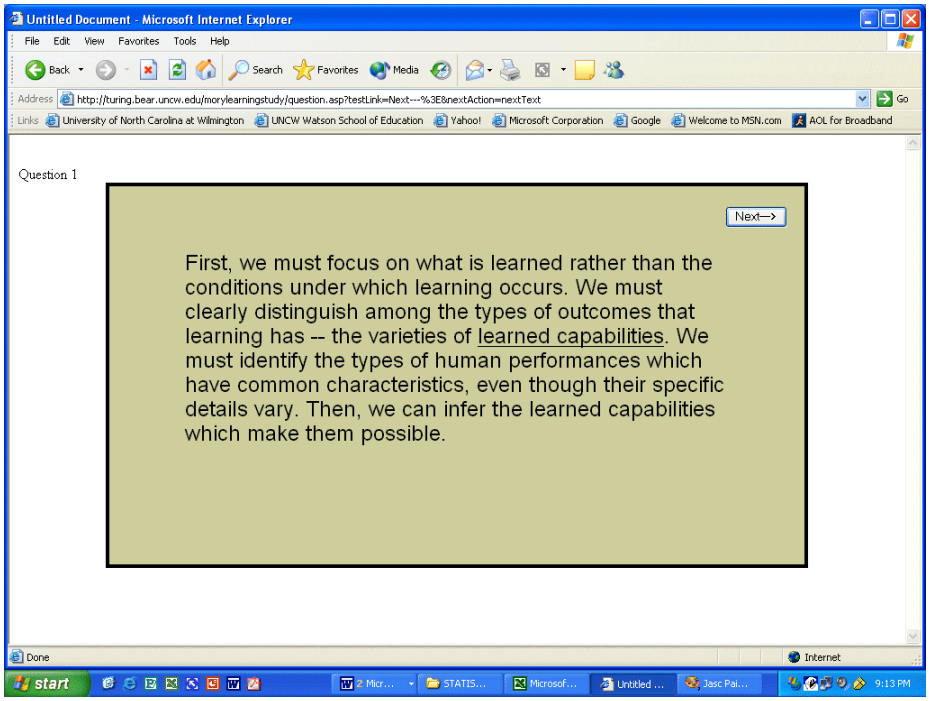
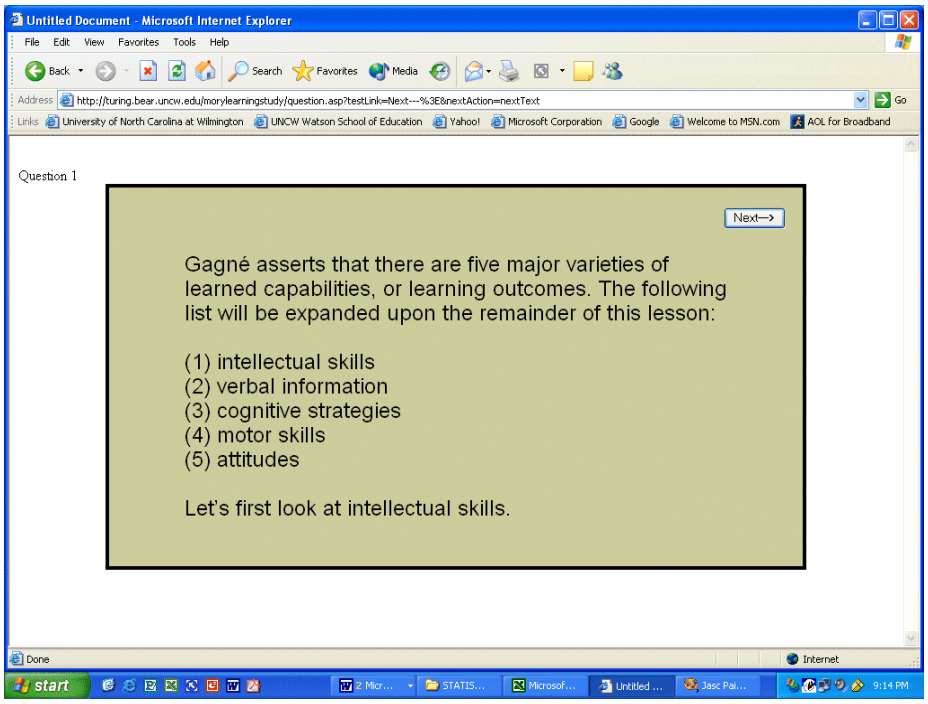


Figure 2. Sample pretest question screen.

Following the pretest and the directions for the tutorial, students were presented screens containing instructional text (see Figures 3a. and 3b.). The design of each question in this section was different from the design of questions used in the pretest and the posttest. These questions were presented within the tutorial, inserted at critical learning points, to help aid students understanding. The "inserted" questions have as few as two, and as many as four, answers choices. The type of learning being reinforced through the use of inserted questions within the text qualifies as verbal information or "verbatim" information as defined with Gagné's (1985) taxonomy. The tutorial information screens present, in detail, the various elements of his taxonomy.



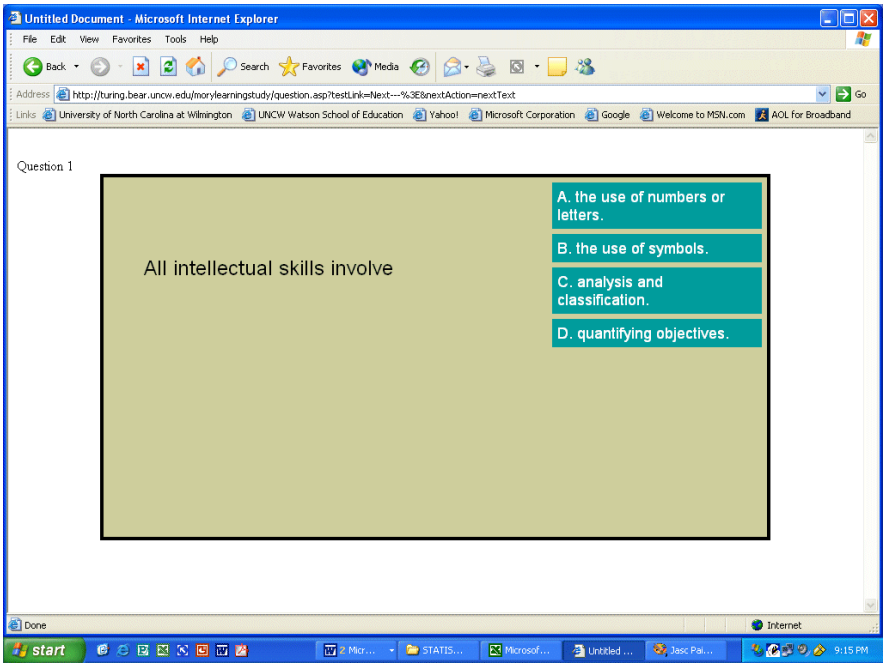
a.



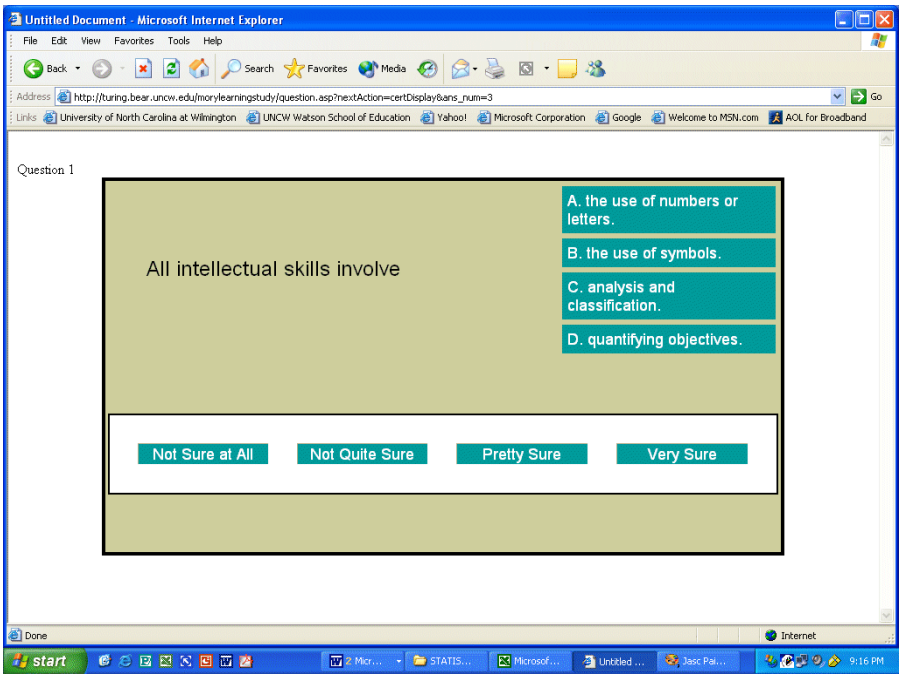
b.

Figure 3. a., b.) Sample presentation screens containing instructional text.

Figure 4a. displays an example of an inserted verbal information question screen. After a question had been answered in the adaptive tutorial, the participants then were presented with an overlay pop-up window inquiring about their level of certitude. Figure 4b. displays the four levels of certainty asked of the students: not sure at all, not quite sure, pretty sure, and very sure. After the participant selected a level of certainty, the lesson proceeded to the feedback information screen.



a.

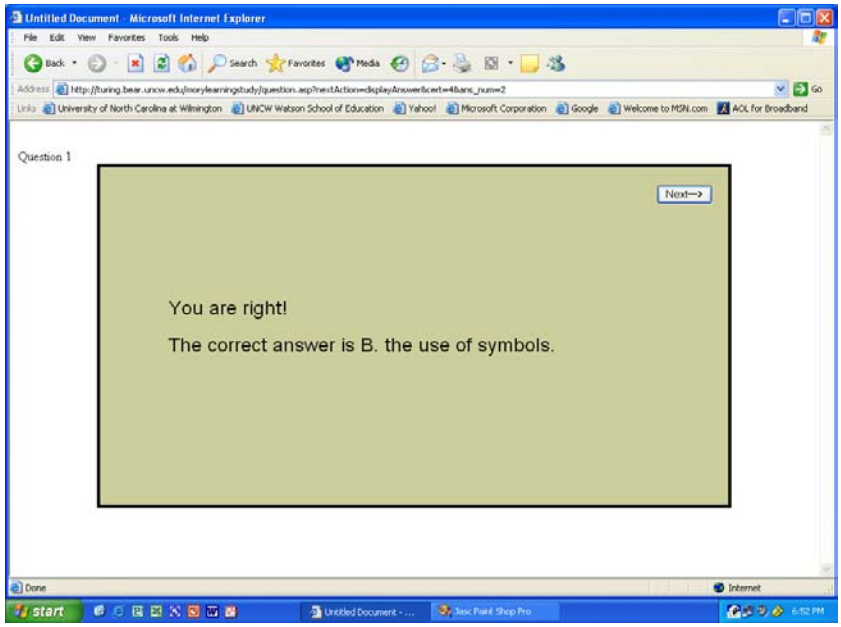


b.

Figure 4. a.) Sample inserted verbal information question.
b.) Sample certitude screen for verbal information test items.

Within the adaptive form of the lesson, there were four possible combinations of correctness and level of certitude (high certitude/correct, high certitude/wrong, low certitude/correct, and low certitude/wrong) that determined one of three types of feedback given to students. The feedback given to high or low certitude corrects was unique to the level of certitude. Figure 5a. represents the feedback given to the students whose answers were correct with a high level of certitude. Only verification and knowledge of correct answer were given to the high certitude/correct combinations, because prior research (Kulhavy, Yekovick & Dyer, 1976; Kulhavy & Stock, 1989; Mory, 1991, 1994) indicates that when a student is both correct and confident that he or she is correct, that student will spend minimal time studying feedback. Therefore, elaborations added to feedback would likely not be necessary nor utilized in response to correct answers with a reported high level of certainty.

Figure 5b. is a representation of the feedback given to students whose answers were also correct, but who indicated a low level of certitude. In this situation, although the student is correct, the low level of certitude indicates the need for elaboration. Low certitude responses suggest lack of understanding and confidence, both of which would likely result in a student maximizing the use of feedback information.



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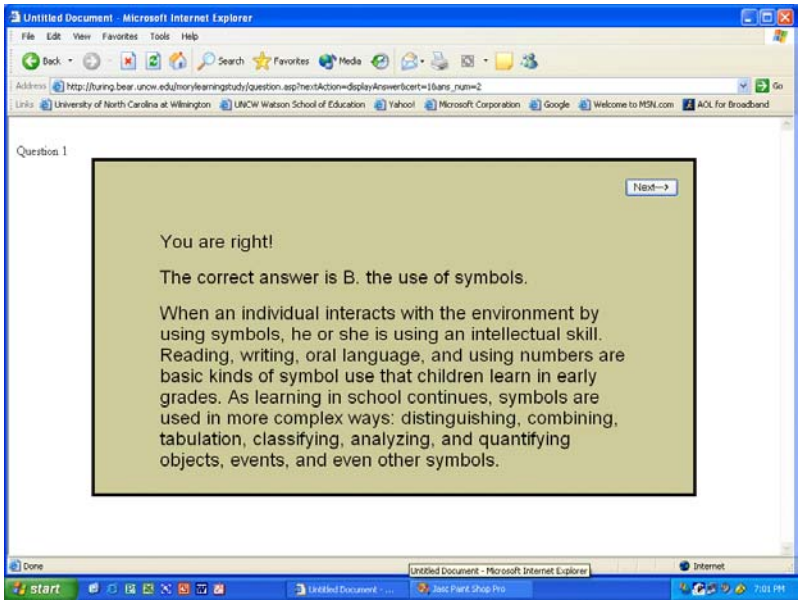

b.

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Figure 5. a.) Sample adaptive feedback for verbal information high certitude/corrects.
b.) Sample adaptive feedback for verbal information low certitude/corrects.

The feedback given to the wrong responses, however, was the same regardless of the level of certitude. Figure 6. presents a sample of the feedback given in response to both the high and low certitude/wrong answers. Regardless of certitude level, a wrong answer indicates a lack of understanding of the material. Consequently, it is believed that learners are more likely to utilize information contained in feedback presented after errors. It is the premise of this study that these learners will spend more time studying feedback after a wrong answer.

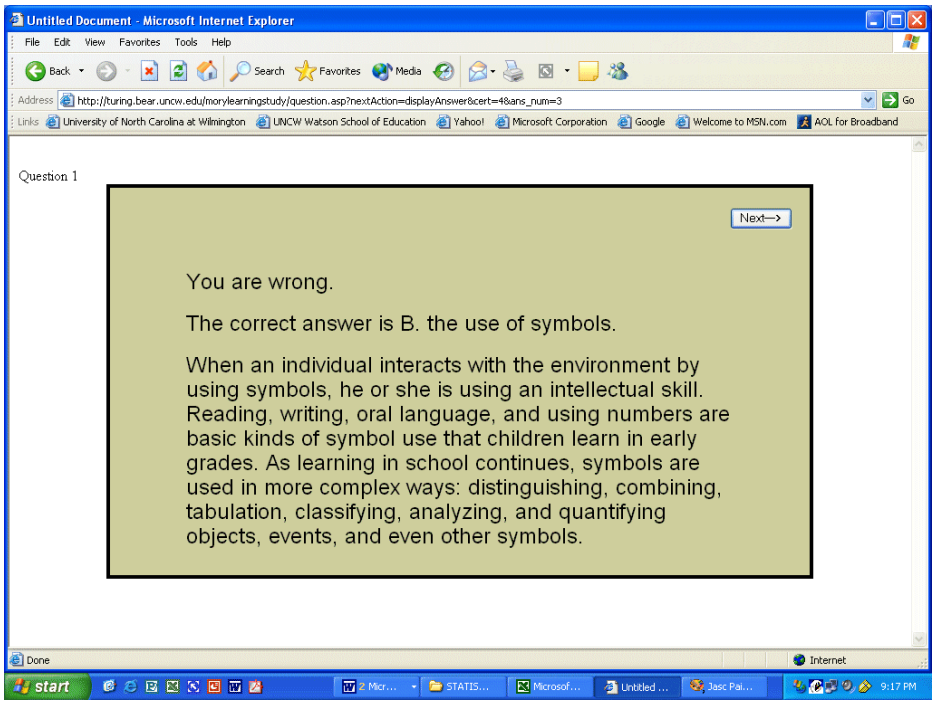
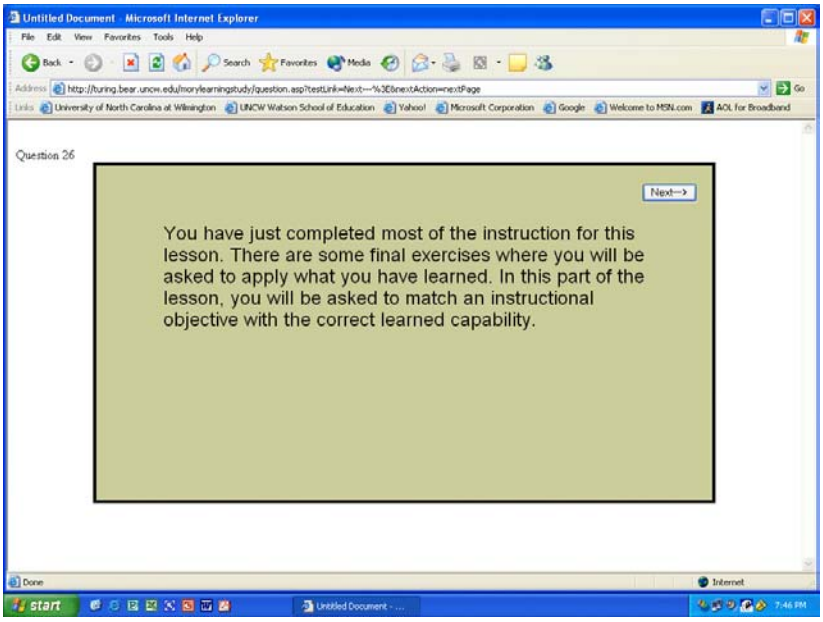


Figure 6. Sample adaptive feedback for verbal information high and low certitude/wrongs .

The tutorial continued to present instructional material with inserted questions where they fit logically. By the end of the instruction, the students had been presented with a total of 25 inserted verbal information questions. After completing the last inserted question, the participants were presented with the directions (see Figures 7a. and b.) for the posttest -- the culminating event of the instructional session.



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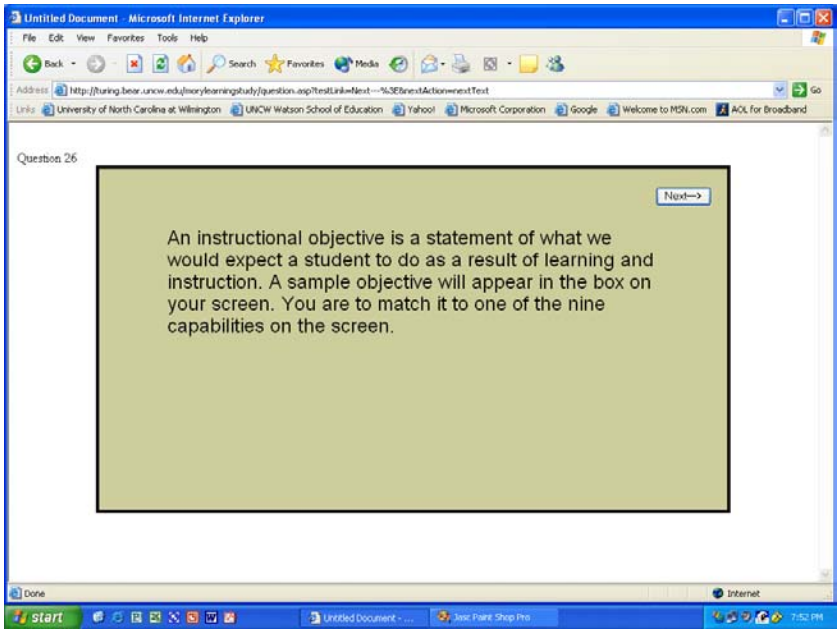
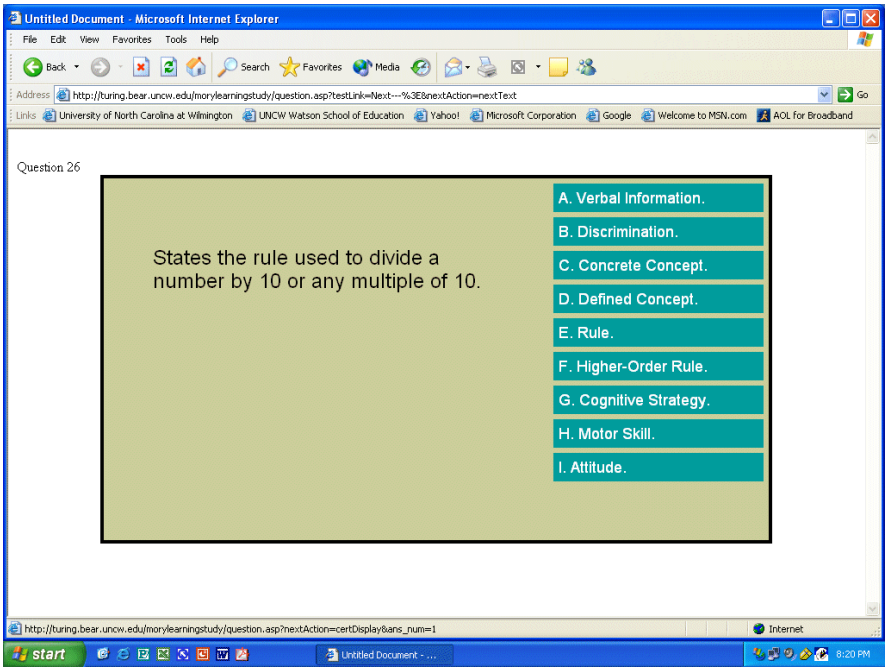


b.

Figure 7. a., b.) Segue directions from tutorial session to posttest.

The last element of the online lesson was the presentation of a 27-item posttest. These items remained adaptive in nature, with feedback variations based on a combination of correctness and level of certitude. As was previously mentioned, the items in the posttest were designed to present a new example of a defined concept, with nine possible classification choices. Again, the use of this type of question reflects Gagné's conditions for learning a concept level task.

Figure 8a. contains an example of a posttest defined concept question. After each posttest question had been answered, a pop-up window appeared that required the learner to reflect upon their certainty about the answer they chose. Figure 8b. displays the four levels of certitude asked of the students, based upon a Likert-scale continuum from "not sure at all," to "very sure." After the participant selected a level of certainty, the lesson provided feedback on a new screen, with the amount of information in the feedback adjusted based upon correctness of answer and level of certitude.



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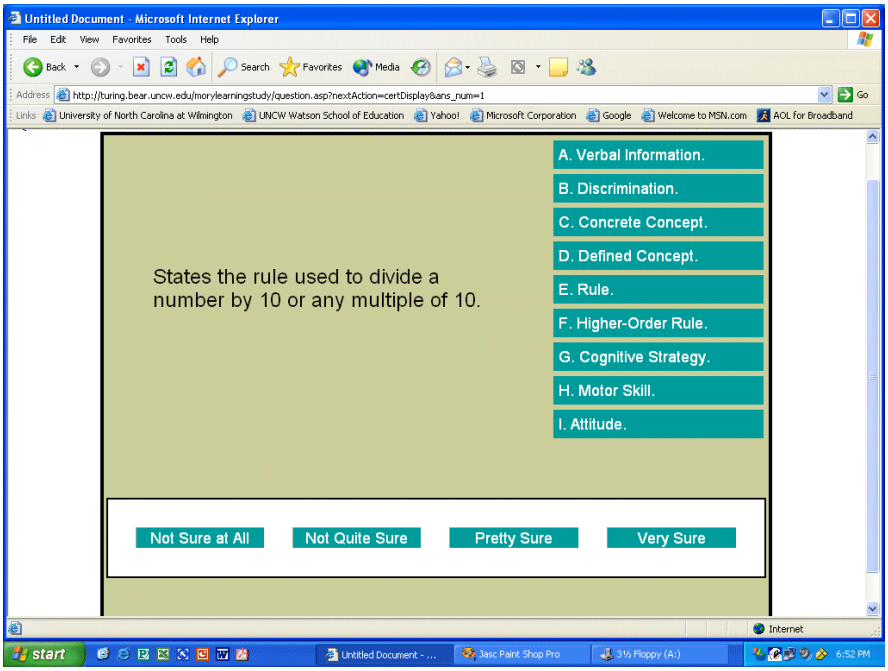
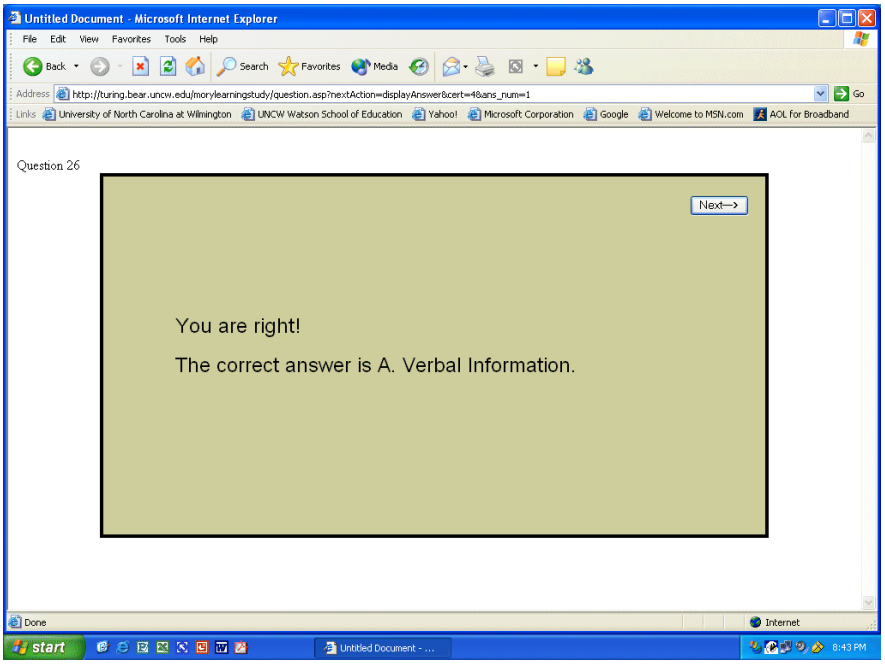


b.

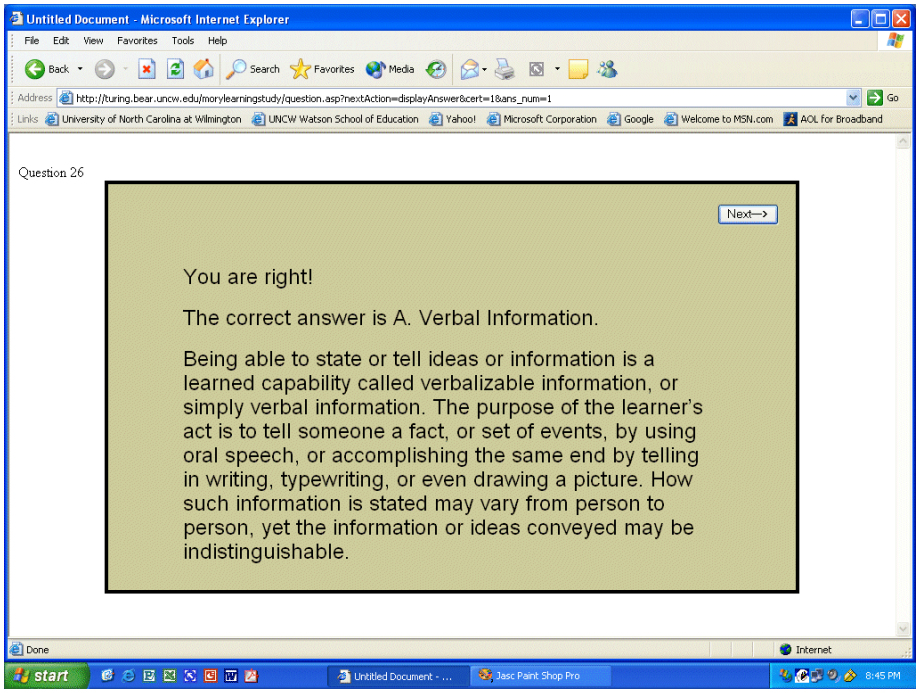
Figure 8. a.) Sample posttest defined concept question.
b.) Sample posttest certitude screen for defined concept test items.

Figure 9a. displays a sample screen containing the feedback given to the students who answered correctly with a high indication of confidence. Only verification and knowledge of correct answer were given to the high certitude/correct combinations. This type of feedback was based on findings of past research (Kulhavy, Yekovick & Dyer, 1976; Kulhavy & Stock, 1989; Mory, 1991, 1994) that when a student is both correct and sure that he or she is correct, that student will spend minimal time studying feedback. Therefore, any elaborations or extra information in feedback would likely not be utilized.

Figure 9b. is a representation of the feedback given to students whose answers were also correct, but who had a low level of certitude. In this case, although the student is correct, the low level of certitude indicates the need for elaboration. Low certitude responses suggest lack of understanding. The elaboration given in the feedback screens was taken directly from the instructional screen that learners had previously seen.



a.



b.

Figure 9. a.) Sample adaptive feedback for defined concept high certitude/correct from posttest.
b.) Sample adaptive feedback for defined concept low certitude/correct from posttest.

As was provided within the tutorial portion of the lesson, the feedback given to errors during the posttest was the same regardless the level of certitude. Figure 10. represents the feedback given to both the high and low certitude wrong answers. As emphasized before, wrong answers indicate that the student did not retain or understand the material addressed by the question. For all errors, feedback was presented that contained verification, the correct answer identified, in addition to a statement of the critical attributes of the concept. In these cases, more information was provided in the feedback, and consequently the feedback study time should be higher.

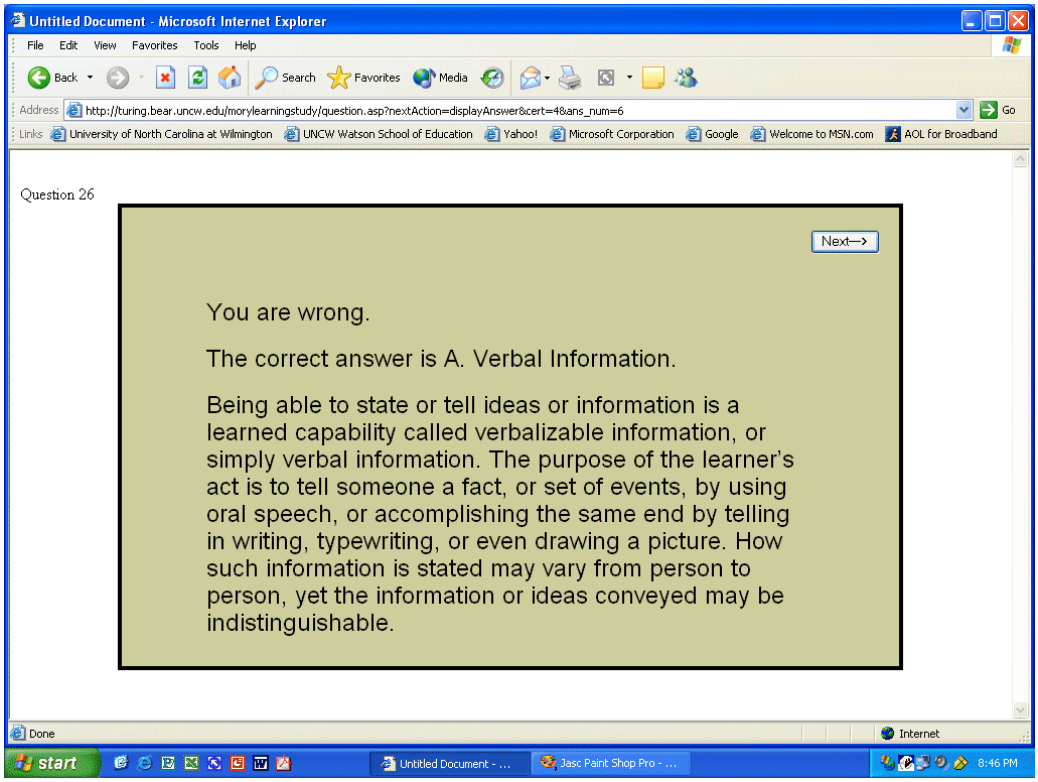
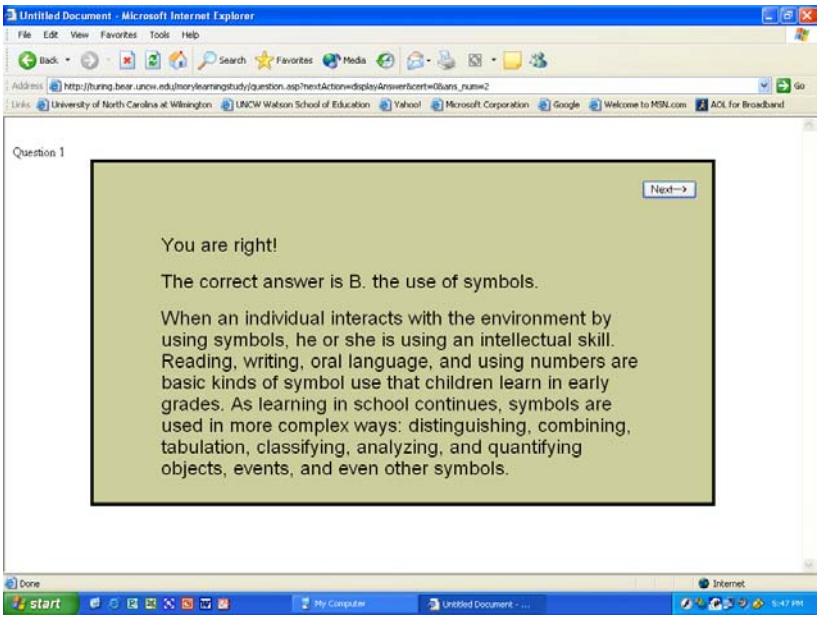


Figure 10. Sample adaptive feedback for defined concept high and low certitude/ wrongs from posttest.

The nonadaptive version of the lesson was presented to half of the study participants. Both groups were presented with exactly the same questions and instructional text throughout; the difference between the two versions was the type of feedback given to the learners. As in the adaptive version, no feedback was given during the pretest section. In the tutorial with the verbal information inserted questions, each feedback screen informed the learner whether his or her answer was correct or wrong. The elaboration in both the correct and wrong screens (see Figure 11a. and 11b.) is also identical.



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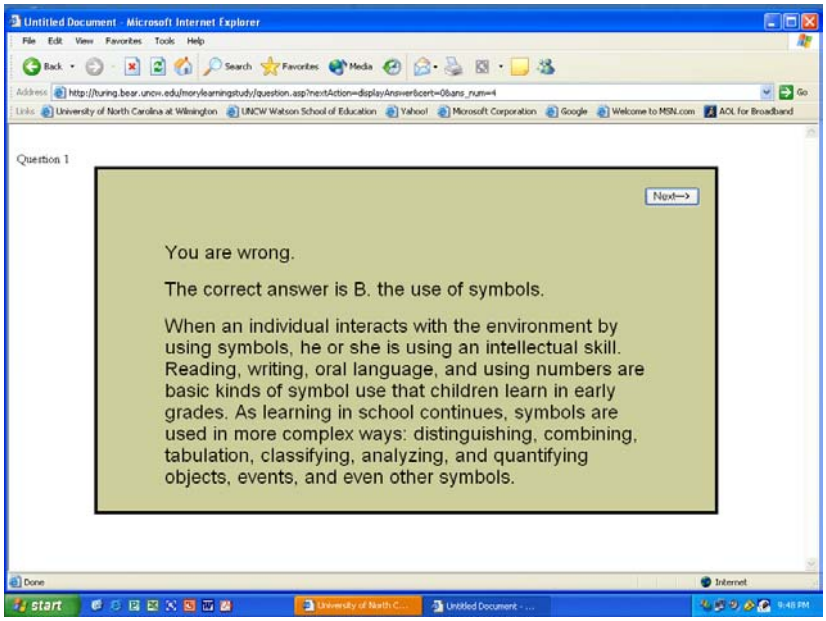
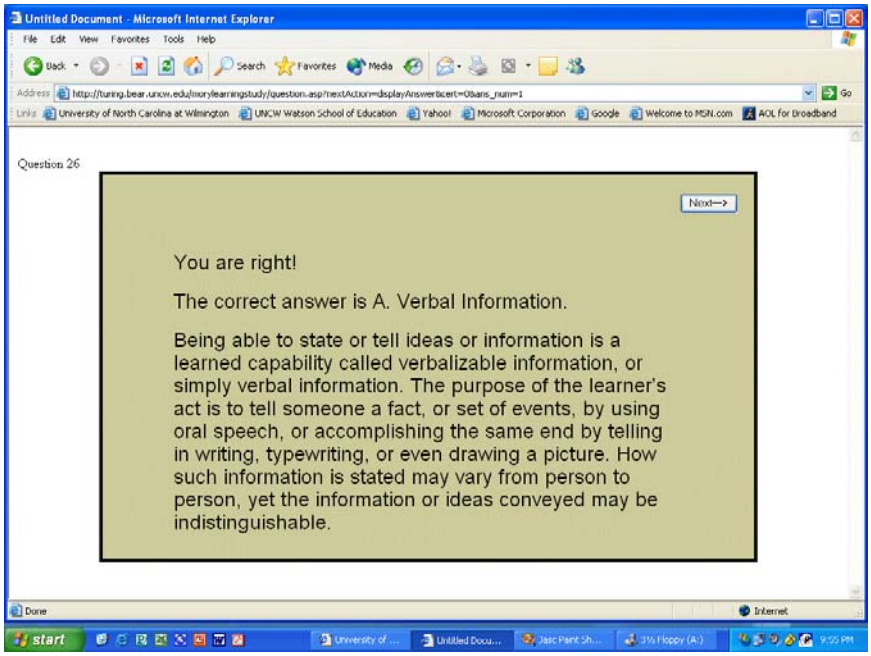


b.

Figure 11. a.) Sample nonadaptive feedback for verbal information corrects.
b.) Sample nonadaptive feedback for verbal information wrongs.

Just as had been sequenced in the adaptive version of the lesson, a posttest was presented at the end of the nonadaptive tutorial. In the nonadaptive version, each posttest answer was a followed by a feedback screen indicating verification of the correctness, knowledge of correct response, and critical attributes of the particular concept which is identical for both correct and wrong answers (see Figure 12a. and 12b.). In order for students to be successful in understanding a concept well enough to classify an example of the concept correctly, they must fully comprehend and recognize the critical attributes of that concept.



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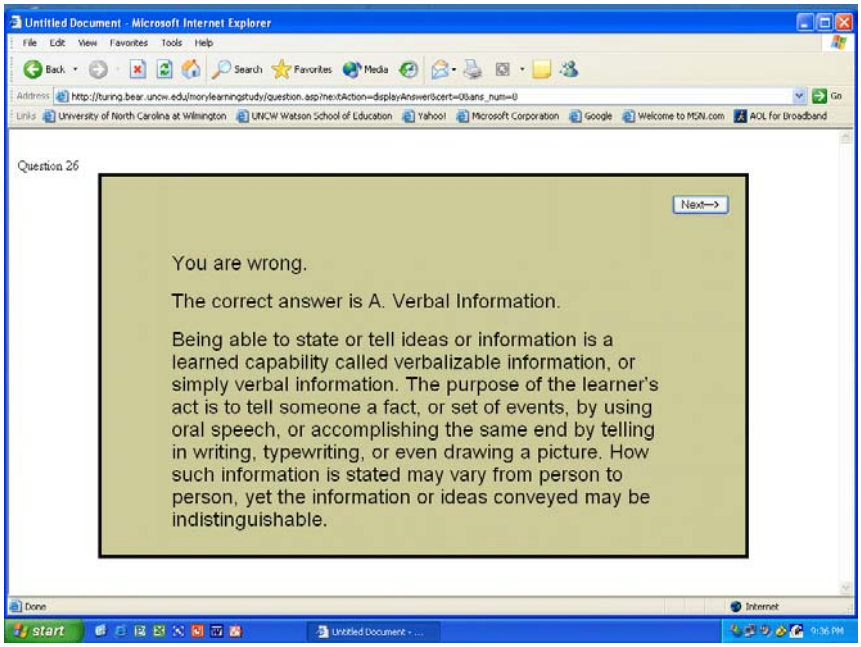

b.

Figure 12. a.) Sample adaptive feedback for defined concept correct from posttest.
b.) Sample adaptive feedback for defined concept wrong from posttest.

When the participants were given feedback after their last posttest response, they were taken to an appreciation and thanks screen for taking part in this research study (see Figure 13.). Even though the students received knowledge of correct response for each item in the posttest, they were not given a final grade or overall score.

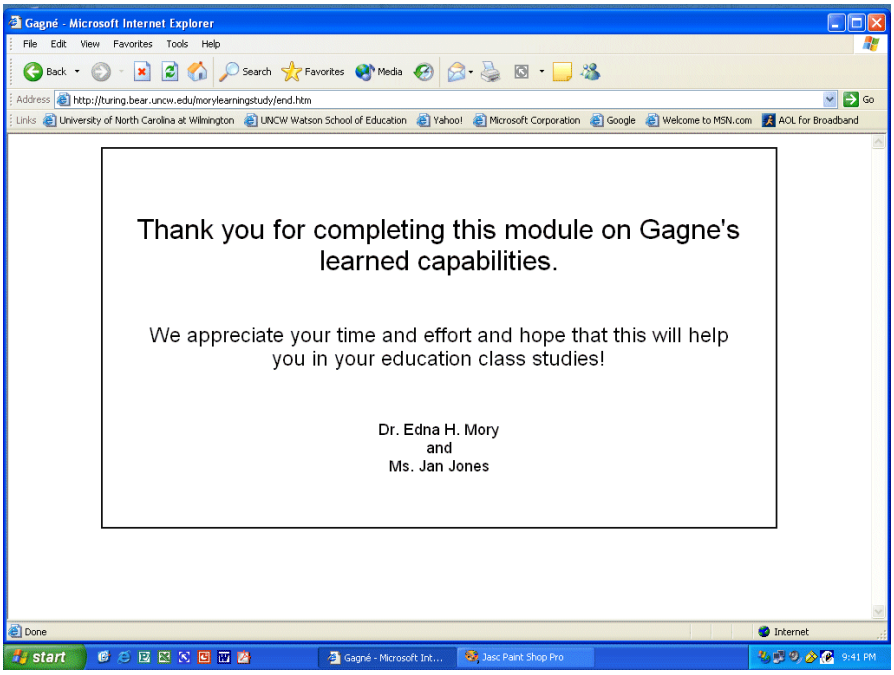

Figure 13. End of session screen.

Subjects

Undergraduate students enrolled in selected courses within the Watson School of Education at UNC-Wilmington were used as the subjects for this study. The courses were chosen based for strong subject relevance and lower likelihood that students' would have knowledge of Gagné's conditions of learning at the point of tutorial instruction. These include sections of EDN 301, 203, and 200. Students participated in the study on a volunteer basis, with no effect on their course grades according to performance.

Data Collection

Procedure

In the Mory (1991) study, no more than six students at a time went through the CBI lesson so that students could be monitored at all times. The computer recorded answer choices for inserted questions, certitude assessments where appropriate feedback study time, and total lesson completion (Mory, 1991). In the present study, students participated in similar tutorial, but design for and delivered via the Web. The basic premise behind Web-based education is that learners can participate in an online session at the time of their choice based within the parameters and requirements of the course. That being the case, this Web-based experimental lesson was presented to the students as a typical online class session. During the designated days the lesson was available on the Web, the learners could access and complete the lesson at any time and from any location that had a computer and Internet connectivity.

Similar to conditions in Mory's (1991) study, the tutorial lesson session was not time-limited; but it was time-constrained. In other words, learners were required to finish the entire lesson in one session. If they exited the lesson before finishing all of its

requirements, they would have to start over at the beginning upon return to the task. Students were advised to access the lesson during a time period in which they could complete it.

Potential test subjects were selected based on classes in which they were enrolled. The best candidates would be enrolled in EDN 200, 203, 301, 303 spring semester 2004. These specific courses were chosen because they are made up of students who have not yet studied the topics that would be presented in the Web-based instruction tutorial, but who would be covering the topics later in their education studies. Because students in these courses will be studying related learning theories, objective writing, and the overall teaching and learning process, the information in the tutorial should be relevant and applicable for these groups.

A letter was sent to the individual instructors teaching 21 sections of the selected classes during the latter part of fall semester 2003 (see Appendix A.). The letter described the study and its purpose. The bottom part of the letter included a returnable permission form that was to be detached and returned, indicating which classes could be visited during the spring 2004 semester during the beginning weeks of spring semester. Of the 18 instructors who were contacted, nine agreed to have their students in 11 class sections participate in the study.

Because the study involved the use of human subjects, required training, approval, and sign-off was required by UNCW's Institutional Review Board (IRB). IRB is responsible for ensuring that all research using human subjects conducted at UNCW, or by UNCW faculty, staff, and students at any location, complies with federal and state regulations. To ensure that researchers involved in this study met IRB requirements, they

completed required Web-based training, entitled *Human Participant Protection Education for Research Teams,* sponsored by the U.S. Department of Health and Human Services and the National Institutes of Health. Certificates of completion were submitted to the IRB before completion and review of the Human Subjects Consent and Human Subjects Protocol forms. In addition to a review of the protocol form, the IRB had to approve the Human Subjects Consent form that the student subjects would receive and be required to sign. Appendix B. contains the official approval granted by IRB for the protocol used in this study.

This author and her thesis professor, Dr. Edna Mory, visited all 11 classes. During the class visits, each student present was given a copy of the UNCW Human Subjects Consent Form for their records, describing the study and students' rights as volunteer study participants. The students were given a secondary copy of the consent form which was to be signed and returned to the researcher. During the brief visits to the classes, the content of the Human Subjects Consent Form (see Appendix C.) was discussed, including an overview of the purpose of the study, students' rights as study participants, activities that would be involved during the study, instructions for accessing the Website, and estimated time investment that would be required by a student participant. Students were informed that they would be enrolled in the study using their individual student ID number. On the consent form signature portion (see Appendix D.), study volunteers were asked to provide the researchers with their student ID number and an email address. While students could be identified by ID number or email address, anonymity was insured throughout, as this information would not be used except for log-in access and communication. The students' were informed that the data from this study

would not be made public in any way that would reveal any individual's identity. Volunteers were informed that access to the Web site would not only be accessible to them between the dates of January 29, 2004, and February 28, 2004,. In addition to face-to-face class visits, two online classes were invited to participate in the study through announcements in their online course. These students were required to either bring, mail, or fax their consent forms to their professor.

As the investigator enrolled students into the online system, the computer randomly assigned each enrollee to one of two different treatment groups. After a student was successfully enrolled, an email message was sent to each one to inform them of their enrollment and access to the Web site. The URL address and log in instructions were given to the student both during the initial class visit and in the enrollment email confirmation.

Two versions of the lesson were prepared to allow for study of the two treatments of adaptive and nonadaptive. The instruction in the two forms of the lesson was identical. Treatments were different in type of question and feedback they would receive. The nonadaptive treatment would provide a fixed form of feedback to the student after each question response. The adaptive treatment included the addition of questions about levels of confidence (referred to in feedback literature as "response certitude") and a varying ("adaptive") type of feedback.. In the adaptive version, the tutorial presented a response certitude question item after each students' response to a practice question. Students were required to determine their level of confidence in each answer they chose. The adaptive group's feedback was based on a combination of answer correctness (correct/wrong) and certitude (high/low).

RESULTS

Profile and Statistics of Respondents

The target population (N= 532) for this study consisted of all students enrolled in the courses EDN 200, 203, 301, and in three section of 303. Nine instructors allowed accessibility to 11 classes, resulting in an accessible population of 338 students. However, 25 of the 338 were not present in class the day the visits took place. Of those students who were present to hear the presentation, 139 agreed to participate and were enrolled in the study. Of the 139 potential participants, 10 were removed from consideration because of the lack of an active email address. They could not be contacted to inform them that they had been enrolled in the study. Of the remaining 129 students, five completed only the pretest portion, so they were eliminated. This left fifty-one percent (n=65) of the initial student volunteers who actually completed the tutorial pretest, lesson, and posttest. When compared to the total number of students who were elicited to participate (338), 20% (n =65) of the total number of students enrolled in the appropriate classes actually participated in the study.

Pre- to Posttest Performance Improvements

When comparing adaptive to nonadaptive treatments, the first question examined whether there were any differences between the two groups in improvement from pre- to posttest. Table 2 presents descriptive statistics regarding overall pre- to posttest improvement scores.

A one-way analysis of variance (ANOVA) resulted in a finding of no statistical differences between the two groups ($p = 0.978$). Both the adaptive and nonadaptive groups improved at the rate of approximately ten percent from pre-instruction scores (pre-test) to post-instruction scores (posttest).

Table 2. Overall Means and Standard Deviations of Pre- to Posttest Performance Improvements for the Two Treatment Groups

Feedback Group	Mean*	SD	N
Adaptive	10.84%	16.08	32
Nonadaptive	10.96%	12.91	33

*p = 0.978

Feedback Study Time

How does the level of posted certitude influence feedback study time? An analysis (ANOVA) of adaptive group errors was conducted and revealed that students whose errors were high certitude instances studied the feedback .88 seconds longer than the students who made low certitude. This difference, however, is not considered significant ($p = 0.091$). See Table 3 for means and standard deviation for low and high certitude errors.

Table 3. Overall Means and Standard Deviations of Feedback Study Time for Low and High Certitude Errors in the Adaptive Group

Feedback Group	Mean*	SD	N
Low Certitude Errors	2.44 seconds	1.41	32
High Certitude Errors	3.32 seconds	2.24	33

*p = 0.091

An ANOVA was performed to compare feedback study time differences for high/certitude correct responses versus all other response combinations for verbal information questions alone. For verbal information feedback study time, cases of high certitude/correct responses had significantly less feedback study time expended than any of the other combinations of high certitude/wrong, low certitude/correct, and low certitude/wrong ($p = 0.006$). See Table 4 for overall means and standard deviations for these groups.

In the instances of high certitude correct responses, feedback contained verification plus knowledge of the correct answer. All other groups received verification, knowledge of correct answer, and elaboration from the lesson. Feedback study time was less in the feedback that contained less information, which is what would be expected. This result provides a verification that feedback load (the amount of information contained in the feedback) alone would have the anticipated effect.

Table 4. Overall Means and Standard Deviations of Feedback Study Time for High Certitude Corrects versus all Other Combinations for Verbal Information in the Adaptive Group

Feedback Group	Mean*	SD	N
High Certitude Corrects	2.53 seconds	0.63	25
Others (HC/W, LC/C, LC/W)	3.78 seconds	2.05	25

*p = 0.006

Similarly, an ANOVA was performed to compare feedback study time differences for high/certitude correct responses versus all other response combinations for concept question items alone. In concept learning, feedback study time was significantly less during instances of high certitude/correct responses than in any of the other combinations of high certitude/wrong, low certitude/correct, and low certitude/wrong ($p = 0.049$). Table 5 reports the overall means and standard deviations for the two groups.

Just as utilized for verbal information questions, cases of high certitude correct responses for concepts were followed with feedback containing verification plus the knowledge of correct answer. All the other groups received verification, knowledge of correct answer, and elaboration that contained salient attributes of the concept from the lesson. Feedback study time was less for feedback containing less information, which again supports expectations based upon feedback load.

Table 5. Overall Means and Standard Deviations of Feedback Study Time for High Certitude Corrects versus all Other Combinations for Concept Learning in the Adaptive Group

Feedback Group	Mean*	SD	N
High Certitude Corrects	2.38 seconds	0.699	25
Others (HC/W, LC/C, LC/W)	2.95 seconds	1.29	25

*p = 0.049

One-way analysis of variance (ANOVA) was used to examine the verbal information alone for differences in feedback study time between cases of correct and wrong responses, regardless of certitude level. Feedback study time was higher for both high certitude/wrong and low certitude/wrong answer combinations. The average feedback study time for errors was significantly greater at 4.11 seconds than for corrects at 2.56 ($p = 0.004$). These feedback study time means and standard deviations are displayed in Table 6.

Table 6. Overall Means and Standard Deviations of Feedback Study Time for High And Low Certitude Wrongs versus High and Low Certitude Corrects for Verbal Information in the Adaptive Group

Feedback Group	Mean*	SD	N
High and Low Certitude Wrongs	4.11 seconds	2.47	25
High and Low Certitude Corrects	2.56 seconds	0.63	25

*p = 0.004

Another ANOVA was completed on concept item questions, revealing significantly greater feedback study time for both high certitude/wrong and low certitude/wrong instances ($p = 0.022$). The average feedback study time after error responses on concept items was 3.16 seconds, while correct response average feedback study time was 2.73 seconds. Feedback study time means and standard deviations for concept errors are displayed in Table 7.

Table 7. Overall Means and Standard Deviations of Feedback Study Time for High And Low Certitude Wrongs versus High and Low Certitude Corrects for Concept Learning in the Adaptive Group

Feedback Group	Mean*	SD	N
High and Low Certitude Wrongs	3.16 seconds	1.81	27
High and Low Certitude Corrects	2.73 seconds	1.39	27

*p = 0.022

Discrimination Error

In the area of concept learning, errors can be classified into cases of fine and gross discrimination types, depending upon how close the error classification is to the original concept and its critical attributes. All concept item response choices were rated in advance by the researcher to determine what answer choices would qualify as a fine or gross error.

An ANOVA test on concepts alone indicated that more time was spent on feedback after the learner made a fine discrimination error rather than a gross discrimination error. On fine discrimination errors, students spent an average of 3.47 seconds studying feedback, while in cases of gross discrimination errors they spent 2.27 seconds on average. This difference was significant at the .046 level ($p = 0.046$).

Table 8. Overall Means and Standard Deviations of Feedback Study Time for Fine And Gross Discrimination Errors in Concept Learning

Error Type	Mean*	SD	N
Fine Discrimination Errors	3.47 seconds	2.85	27
Gross Discrimination Errors	2.67 seconds	1.13	27

*p = 0.046

When considering the relationship between certitude level and discrimination in concept learning, high certitude errors were examined to determine if they correlate with fine discrimination errors. A non-parametric test had to be utilized for this analysis, since the variables for the test (fine/gross and high/low) are nominal. The McNemar Change Test (see Siegel & Castellan, 1988) using a four-fold table of frequencies indicated that fine errors do correlate significantly with high certitude, and that gross errors correlate with low certitude ($p < 0.001$).

Efficiency

To calculate feedback efficiency, the total number of correct answers on the posttest was divided by the total feedback study time for each student. This resulted in a feedback efficiency ratio for each student. The purpose was to determine whether feedback efficiency between the nonadaptive and adaptive treatments was significantly different. A one-way analysis of variance (ANOVA) produced a mean for the nonadaptive group of 0.19, while the mean for the adaptive group was 0.25. The feedback given to the adaptive group was more efficient in terms of posttest correct results ($p = .011$). Table 9 displays the means and standard deviation indices for feedback study time efficiency in the two treatment groups.

Table 9. Overall Means and Standard Deviations for Feedback Efficiency Adaptive Versus Nonadaptive Treatment

Lesson Version	Mean*	SD	N
Adaptive	0.25	0.098	32
Nonadaptive	0.19	0.082	32

$p = 0.011$

The final question of the study related to overall lesson efficiency for the two treatment groups of adaptive and nonadaptive. To calculate overall lesson efficiency, the total number of correct answers on the posttest was divided by the total lesson time each student used in completing the entire tutorial. This resulted in a lesson efficiency index for each student, in order to examine expenditure of total lesson time in relationship to total number of correct answers on the posttest. The purpose was to determine if lesson efficiency for the nonadaptive group was better than the adaptive group. A one-way analysis of variance (ANOVA) produced a mean for the nonadaptive group of 0.022, while the mean for the adaptive group was 0.029 ($p = .12$). Neither group was more efficient than the other in terms of total lesson efficiency. Table 10 displays the means and standard deviation indices for overall lesson efficiency for the two treatment groups.

Table 10. Overall Means and Standard Deviations of Lesson Efficiency for Adaptive Versus Nonadaptive Treatment

Lesson Version	Mean*	SD	N
Adaptive	0.029 seconds	0.020	32
Nonadaptive	0.022 seconds	0.013	32

*p = 0.119

DISCUSSION

Pre- to Posttest Performance Improvements

In the comparison of adaptive versus nonadaptive treatments, the first research was whether there are any differences in improvement between pre- and posttests? This question examined the amount of *improvement,* as measured by the students' ability to classify new examples of the concepts taught. Typically, pre- and posttests use the same test items. However, to have done so in this study would have changed using defined concepts learning outcomes to be, instead, simple "verbal information." If the task had been to examine the successful learning of verbal information learning outcomes, questions would involve the statement of facts, and it would appropriate to simply use the same question again on the posttest. However, the pre- and posttests were measuring the student's ability to classify examples of concepts. This intellectual skill requires that only new, unvisited, examples be used in assessing the acquisition and understanding of the concept. If the same set of example items had been used across the pre- and posttests, a student's improvement could be due to having seen the concept information earlier. The only way to know that students understand the critical attributes of a concept is to present a new instance or example to classify.

A one-way analysis of variance (ANOVA) resulted in a finding of no statistical difference between the two groups ($p = 0.978$). Both groups improved at the rate of approximately ten percent. One rationale for this outcome may be that students are unable to accurately predict their levels of correctness in higher cognitive tasks (Mory, 1991).

Feedback Study Time

How does the level of posted certitude affect feedback study time? An analysis (ANOVA) of the adaptive group errors shows that the students who made high certitude errors studied the feedback .88 seconds longer than the students who expressed low certitude. It would be expected that in the case of high certitude errors, students will typically spend more time studying feedback regardless of the amount of feedback content. This difference, however, is not considered significant ($p = 0.091$) in this study.

One reason that could explain this result is that the amount of information included in error feedback in the adaptive group was identical, irrespective of certitude level. Prior studies (Kulhavy, 1977; Kulhavy & Stock, 1989) have shown that a high certitude error typically results in a student expending extra time in feedback reconcile the discrepancy between this expectation. However, this trend is not supported, particularly given the controlled element of identical feedback information load. Further, any type of error represents misinterpretation or some lack of understanding. Students may innately spend more time on feedback given after error responses of any type to correct the misunderstandings.

Feedback study time differences for high/certitude correct responses versus all other response combinations were the same for verbal information and concept questions alike. Obviously verbal information is a lower level learning task, while concept classification involves higher cognitive processing. Cases of high certitude/correct responses had significantly less feedback study time than any of the other combinations for both learning types. In the cases of high certitude correct responses, the feedback

contained verification plus knowledge of correct answer. All the other groups received verification, knowledge of correct answer, and elaboration from the lesson. The only difference in feedback elaboration for concepts was in the content of the feedback elaboration. Feedback study times were lower for feedback that contained less information, which is what would be expected. This result verifies this expectation.

It was important to examine feedback wrong answers versus correct answers, regardless of certitude level. The analysis of the data indicated that feedback study time for both verbal information and concept questions was higher for both high and low certitude/wrong answer combinations. Regardless of how much feedback information was presented, students spent more time studying feedback after wrong answers no matter what their level of certitude or amount of feedback. The average feedback study time for errors in both verbal information and concept questions was significantly greater than feedback study time for correct answers.

Discrimination Error

Within concept learning tasks, errors can be divided into fine and gross discrimination types, depending upon how close the critical attributes of the erroneous concept match the actual correct concept. The analysis on concepts alone demonstrated that more time was spent on feedback after the learner made a fine discrimination error rather than a gross discrimination error. On fine discrimination errors, students spent an average of 3.47 seconds studying feedback, while on gross discrimination errors they spent 2.27 seconds on average. This difference was significant at the .046 level ($p = 0.046$).

Previous studies (Mory, 1994 & 1991) suggest that there is a positive correlation between high certitude and fine discrimination errors. In this study high certitude seemed to correlate with fine discrimination errors. The McNemar Change test that was utilized in this study only determined if any correlation existed between ANY combination of errors, suggesting a significant positive correlation between high certitude and fine errors. However, the opposite trend of low certitude correlating with gross discrimination error was not specifically determined with this test. Mory (1991) utilized another testing method for determining correlation values than the one used in this study. Further testing methods should be employed using data from this study to better identify any cross-correlational trend. If a positive correlation between BOTH sets of instances can be determined using the same data (high certitude errors showing a positive correlation with gross discrimination errors AND low certitude errors suggesting a positive correlation with fine discrimination errors), this would carry stronger support for correlation than the results in this study. Because of the verification of the correlation between high certitude errors and fine discrimination errors, there is some reason to expect the possibility that self-report measures, such as response certitude responses, may not be unnecessary.

Efficiency

To calculate feedback efficiency, the total number of correct answers on the posttest was divided by the total feedback study time for each student. This results in a feedback efficiency ratio for each student. The purpose of this ratio is to determine if feedback efficiency for the nonadaptive group was better than the adaptive group. As Mory stated (1991), "It is easy to see how manipulations of feedback using a prescription which combines information leanness with appropriate effectiveness can lead to very

efficient feedback" (p. 105). As in the Mory (1991) study, adaptive feedback was more efficient than nonadaptive feedback, at least when only examining feedback study times and correct answers. If overall length of time to complete the lesson is not an issue, the finding in this study supports that certain prescriptive manipulations of feedback does, indeed, improve feedback efficiency. The analysis of the data produced a mean for the nonadaptive group of 0.19, while the mean for the adaptive group was 0.25. This indicates that the feedback for the adaptive group is more efficient in terms of posttest correct results ($p = .011$).

The final question of the study related to overall lesson efficiency for the two treatment groups of adaptive and nonadaptive. This study found that neither group is more efficient than the other in terms of total lesson efficiency. What can be inferred from this result is that, while feedback study time alone may be more efficient in correcting errors, this extra expenditure of time to produce the "efficient" adaptations in feedback actually does nothing for improving the overall effectiveness of the lesson. In order to give "efficient" feedback adaptations, the adaptive lesson used in this study required much overall additional time for students to also respond to a related certitude question. Because cost-benefit analyses are crucial in the design of training, researchers must weigh the hard dollar cost of the design with the soft dollar cost, i.e. the amount of time students spend in the lesson.

IMPLICATIONS AND FUTURE RESEARCH

This study was a partial replication of a past study (Mory, 1991) that examined the 1989 Kulhavy and Stock model in an effort to determine if prescriptive adaptive feedback based on a combination of answer correctness and learner response certitude

would be more effective than nonadaptive feedback. Similar results were obtained the current findings as were found in the prior study. If less interruptive and more objective ways of adapting feedback to increase overall lesson efficiency can be identified, then adaptations may indeed be of great overall benefit in saving instructional time.

While the instructional material and test questions from the Mory (1991) study were almost identical to the materials used in this study, environmental conditions were different. The Mory study utilized a CBI lesson conducted in the presence of the researcher. The present study was conducted online and within an environment similar to a typical online instructional session. The study participants were able to access the lesson from the time and place of their choosing. Significant findings from this study indicate that future researchers should continue to explore feedback and other variables within these new environments.

Web-based instruction is not necessarily intended to replace entire programs, but this delivery system may prove beneficial in supplementing existing programs. Mory (1991) suggested that future studies might explore designing lessons to increase feedback study time for low certitude answers in an effort to increase posttest scores. However, designers in Web-based environments are faced with the analysis of the incremental amount of change and the costs associated with design manipulations. Lesson efficiency is a function of time. Design efficiency is a function of capital outlay. The relationship between time and money emphasized in the business world also exists within the "halls of ivy." Because of budget constraints, educational institutions are mandated to look for the most efficient delivery systems at their disposal. Improving lesson efficiency in a

Web-based learning environment is a valuable asset for the institution, students, and instructors.

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APPENDIX

Appendix A. Letter to professors.

November 26, 2003
Dr. Instructor Name
Department of Specialty Studies
University of North Carolina at Wilmington
Wilmington, NC 28403

Dear Dr. Instructor Name:

I am a graduate student in the MIT program. As a part of the requirements for degree completion, I am writing a thesis under the supervision of Dr. Edna H. Mory in the Watson School of Education. The topic of my thesis is feedback study time in a Web-based environment. To go beyond a review of the literature, I plan to conduct an experiment, the results of which will address my research questions.

The basis for the experiment is a Web-based lesson appropriate for beginning education majors. Gagné's Conditions of Learning is the topic of the lesson. Students will be presented with a Web-based instruction introducing information about Gagné's learning capabilities and the classification of types of learning outcomes. They will then practice classifying unique examples of learning outcomes according to the Gagné taxonomy.

In order for the results of my study to be meaningful, I need the participation of as many subjects as possible. Dr. Mory and I would like to invite students in EDN 200, EDN 203, and EDN 301 to participate on a volunteer basis during early spring semester. Because you are an instructor of one of these courses, we are asking you to please allow us access to your students during the second week of spring semester.

As semester classes begin January 7, 2004, we would like to visit as many individual course sections as possible during the week of January 12-16. The Web-based lesson would be available online for the three weeks January 12-31. We will need approximately 15 minutes to speak with your class at its second or third class meeting.

Please indicate your willingness to participate with us in the study by completing the form below and placing it in Dr. Mory's mailbox in Specialty Studies by December 8, 2003. Dr. Mory and I would like to thank you for your help and cooperation in this effort.

Sincerely,
Jan Jones

----✂----------

Dr. Instructor Name: I would be willing to allow the following sections to participate:

☐ EDN 000-000

Appendix B. IRB approval form.

IRB Human Subjects Protocol Form
Effective September 10, 2003

Leave Blank
Protocol #: 2004-509
Approval Date: 1/22/2004
Expiration Date: NA

University of North Carolina at Wilmington
Institutional Review Board
Human Subjects Protocol Form

Title of Project (use same title as grant proposal, if applicable):
The Use of Adaptive Feedback in Web-Based Instruction: Effects on Student Achievement, Feedback Study Time, and Efficiency

Project Type:
☒ **Research** **Proposal #** ____ ***Attach a copy of the proposal**
☐ **Funded** **Account #** ____
Funding Agency*: ☐ DOE ☐ NIH ☐ Other ____
☐ **Under Review**
☒ **Not Funded**
☒ **Student Research**
☐ **Teaching** **Course Number:** ____

Proposed Start Date: 01/21/04 **Proposed End Date:** 01/31/04

Office Use ONLY:
Type of IRB Review: ☐ **Full Review** ☐ **Expedited** ☒ **Exempt**
Results: ☒ **Approved** ☐ **Approved Pending Revisions** ☐ **Deferred** ☐ **Disapproved**

Candace Mauthier, PhD 1/22/2004
Signature of the IRB Chairperson **Date**

☐ **If necessary, revisions/clarification received:** ____
Results: ☐ **Approved** ☐ **Approved Pending Revisions** ☐ **Disapproved**

Signature of the IRB Chairperson **Date**

Principal Investigator: (If student research, PI should be Faculty Advisor)

Name: Edna H. Mory	**Date of IRB Training:** 01/15/04
Title: Associate Professor	**Phone:** 910-962-4175
Department: Specialty Studies	**Fax:** 910-962-3609
Campus Address: King 201-C	**E-mail:** morye@uncw.edu
Mailing Address: 601 S. College Road, UNCW, Wilmington, NC 28403	

A copy of this page, signed by the IRB Chair, serves as formal notice of the approval of, disapproval of, or need to revise this protocol. Expedited and full review protocols, consent forms, and assent/permission forms are effective for ONE year from the date of approval. These protocols MUST be renewed annually. Exempt protocols do not require annual renewal. Any and all proposed changes to this protocol must be submitted to the IRB for approval, regardless of review type.

Appendix C. IRB approved consent form.

The person in charge of this study is Dr. Edna H. Mory (*PI*) of the University of North Carolina at Wilmington. UNCW student, Ms. Delinda (Jan) Jones, will be gathering and analyzing the information for the study.

What Is The Purpose Of This Study?
The purpose of this research study is to examine various types of feedback presented in a Web-based instructional environment on the learning of verbal information tasks and the acquisition and classification of defined concepts. The Web-based environment has not been researched in this area. Additionally, the learning task that will be presented via the Web involves introducing undergraduate students to information about nine learning capabilities (verbal information) typically employed in information-processing and instructional design practices. This study is a partial replication of a study done in 1991 by Dr. Edna H. Mory, Department of Specialty Studies, Watson School of Education, UNCW, to investigate feedback implications in a computer-based environment. Because of the limited research of this topic, it is expected that the results of this study will add to the body of knowledge globally available to researchers who are interested in the topic.

By doing this study we hope to learn how feedback functions in a web-based learning environment.

Where Is The Study Going To Take Place And How Long Will It Last?
The research procedures will be conducted at UNCW. You will need to come to a computer lab or have access to a Windows PC connected to the Internet. If you exit at any time prior to the conclusion of the lesson, you must start over again at the beginning. Once you complete the posttest and end the lesson, further access to the Website using your username will be blocked. The anticipated completion time of this activity is 45 minutes. Each visit to complete a lesson will take about 45 minutes. The total amount of time you will be asked to volunteer for this study is 1 hour over the next 10 days.

What Will I Be Asked To Do?
You will need to have access to a Windows computer with Internet access and connectivity. As a study participant, you will be given a Website address (URL) to go to for the study material. You will enter the website using a unique Username and Password.

Once you have logged in, you will complete an online pretest made up of multiple-choice questions relating to the material in the tutorial. After the pretest, you will proceed to the actual tutorial lesson material. You will be randomly assigned to an adaptive feedback or non-adaptive feedback group. The tutorial will consist of screens of text information, with inserted multiple-choice questions and feedback to help you understand the material. You will then take a posttest on the material in the lesson. If you exit at any time prior to the conclusion of the lesson, you must start over again at the beginning. Once you complete the posttest and end the lesson, further access to the Website using your username will be blocked. The anticipated completion time of this activity is 45 minutes.

The Website will be available between the dates of Wednesday, January 28st and Sunday, February 8th. You may access the Website at your own convenience during this time period, from any computer and at any time of the day you choose.

Your **Username** for this study will be your **UNCW Student ID number** (no spaces or hyphens). This Username will NOT be shared in any form with others, nor will it be used in any way that will reveal your identity in the study. Your anonymity is ensured throughout the study and in any data resulting from the study.

What Are The Possible Risks And Discomforts?
To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

Will I Benefit From Taking Part In This Study?
You will not get any personal benefit from taking part in this study. However, your participation may help you better understand terminology that will relate to what you will learn in your current course.

Do I Have To Take Part In This Study?
If you decide to take part in the study, it should be because you really want to volunteer. There will be no penalty and you will not lose any benefits or rights you would normally have if you choose not to volunteer. You will not be treated differently by anyone if you choose not to participate in the study. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

What Will It Cost Me To Participate?
There are no costs associated with taking part in this study.

Will I Receive Any Payment Or Reward For Taking Part In This Study?
You will not receive any payment or reward for taking part in this study.

Who Will See The Information I Give?
Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about the combined information. You will not be identified in these written materials.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you.

Can My Taking Part In The Study End Early?
If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. There will be no penalty and no loss of benefits or rights if you stop participating in the study. You will not be treated differently by anyone if you decide to stop participating in the study.

What If I Have Questions?
Before you decide whether or not to participate in the study, please ask any questions that come to mind now. Later, if you have questions about the study, you can contact the investigator, Dr. Edna H. Mory at 910-962-4175. If you have any questions about your rights as a research participant, contact Dr. Candace Gauthier, Chair of the UNCW Institutional Review Board, at 910-962-3558.

Research Participant Statement and Signature

I understand that my participation in this research study is entirely voluntary. I may refuse to participate without penalty or loss of benefits. I may also stop participating at any time without penalty or loss of benefits. I have received a copy of this consent form to take home with me.

_____ _____
Signature of person consenting to take part in the study Date

_____
Printed name of person consenting to take part in the study

____Jan Jones_____ __1/___/04_____
Name of person providing information to the participant Date

Appendix D. Signed consent form.

Please RETURN This Portion to Us!!!

Research Participant Statement and Signature

I understand that my participation in this research study is entirely voluntary. I may refuse to participate without penalty or loss of benefits. I may also stop participating at any time without penalty or loss of benefits. I have received a copy of this consent form to take home with me.

_____ _____
Signature of person consenting to take part in the study — Date

_____
Printed name of person consenting to take part in the study

____Jan Jones_____ __1/___/04_____
Name of person providing information to the participant — Date

Please provide an email address where you can be reached for us to confirm when the site is ready for you.

Name:
_____

Your Email:
_____

Your Student ID Number:_____