DOCUMENT RESUME

ED 397 803 IR 017 991

AUTHOR Kao, Michelle T.; And Others
TITLE Scaffolding in Hypermedia Assisted Instruction: An Example of Integration.
PUB DATE 96
NOTE 22p.; In: Proceedings of Selected Research and Development Presentations at the 1996 National Convention of the Association for Educational Communications and Technology (18th, Indianapolis, IN, 1996); see IR 017 960.
PUB TYPE Reports - Descriptive (141) -- Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Academic Achievement; *Computer Assisted Instruction; Courseware; *Educational Technology; Higher Education; *Hypermedia; Instructional Effectiveness; Instructional Materials; Program Implementation; Teacher Student Relationship; *Three Dimensional Aids; Users (Information)
IDENTIFIERS Prototypes; Purdue University IN; *Scaffolding Model

ABSTRACT

A 3-D contingent scaffolding model of a hypermedia system is proposed which gradually weans learners off the technical support of instructors or more knowledgeable peers as they master certain skills. The model permits the instructor to vary his or her support in response to the learner's performance in a learning task consisting of a sequence of steps/sub-tasks. This paper reports on the implementation of this model in a computer-based instruction program at Purdue University (Indiana) and on a study of its effectiveness. The 3-D contingent scaffolding model in this study is implemented in a computer-based instruction program, "Hypothesis Testing--the Z-Test" in order to establish baseline data for integrated media-based instruction or hypermedia-based learning environment. Findings show evidence that this program does indeed promote knowledge retention and improve independent learning. (Contains 14 references.) (AEF)

Title:

Scaffolding in Hypermedia Assisted Instruction: An Example of Integration

Authors:

Michelle T. Kao, James D. Lehman, Katherine S. Cennamo
Educational Computing and Instructional Development
Department of Curriculum and Instruction
Purdue University

ABSTRACT

To prevent the user from the over-relying on technology support, we propose a 3-D contingent scaffolding model to systematically vary the instructor's support in response to the learner's performance in a learning task consisting of a sequence of steps/sub-tasks. We report on the implementation of this model in a computer-based instruction program here and on a study of its effectiveness. In this study, the 3-D contingent scaffolding model is implemented in a computer-based instruction program, "Hypothesis Testing-- the Z-Test" in order to establish baseline data for integrated-media-based instruction or hypermedia based learning environment. Our findings show evidence that "Hypothesis Testing-- the Z-Test" does indeed promote knowledge maintenance and improve independent learning.

INTRODUCTION

The term "Scaffolding" has been used to describe various instructional techniques for use in learning activities that reflect authentic task situations. This technique has also drawn great attention from the media researchers for media can provide a more realistic learning environment with rich and varied support. One major concept of this technique is to enable the learner to engage in out-of-reach activities; having a "knowledgeable other" or "more capable peer" to bring the learner along; having something or someone "share the cognitive load" (Jackson et al., 1995). However, if we go back to Bruner's original definition of scaffolding (Bruner, 1983), we find there is another valuable key concept of this technique that has usually been neglected. That is, this knowledgeable or more capable other is not only responsible for building the support in learning activities, but also is responsible for fading the support as the learner gradually masters the skill. The Cognition and Technology Group at Vanderbilt University (1993) has proposed a risk of over relying on the support of integrated media. To educate individuals to be independent and active learners, there is a need to emphasize the support-fading component of scaffolding while we try to integrate this instructional technique into any kind of media assisted instruction.

BACKGROUND

Method of Scaffolding

In the past 20 years, the constructivist paradigm has gradually come to educational research. From the constructivism perspective, the purpose of education is to cultivate independent and self-directed learners. Bruner's metaphor of scaffolding provides an explicit strategy to direct our teaching toward this end.

Scaffolding refers to the interactional support that instructors or more skillful peers offer learners to bridge the gap between their current skill levels and a desired skill level. In the process, the amount of support is gradually withdrawn as the learners become more proficient. Ultimately, the learners can complete tasks on their own (Greenfield, 1984). The literature review suggests that scaffolding can enhance comprehension, improve independent learning, and promote knowledge transfer (Bruner, 1983, Greenfield, 1984, Cazden, 1988). Evidence of these advantages has been found in many studies in the field of language and cognitive development (Gallimore et al., 1989; Boyle and Peregoy, 1990; Day and Cordon, 1993).

At the same time, limitations of scaffolding have also been pointed out. This technique has been criticized for its lack of discussion on development of the expert's role in providing the novice with assistance (Gaffney and Anderson, 1991). Its implementation has also been criticized for not being able to capture the challenge of responding to the diversity of children's intentions in classroom teaching (Dyson, 1990).

Scaffolding in Media-Based Instruction

Computers have introduced unprecedented levels of autonomy into education. The processing and integrating capabilities of computers have created an interactive, support-rich, and individualized learning environment. These characteristics might break the limitations of scaffolding and ease the implementation of this instructional technique.

Several researchers have developed scaffolded computer-based instruction, integrating more than one medium to support learners' knowledge construction in authentic learning activities (Steiner & Moher, 1994; Jackson et al., 1995). However, the discussion has been focused on the software development and the support-building models. Only a small amount of qualitative evaluation data have been reported. The support-fading element of scaffolding was not applied in these studies. Therefore, solid scaffolded instruction is not only difficult to built, but also extremely difficult to evaluate.

Leiberman and Linn (1991) contented that scaffolding is one of the several ways computers can be used to encourage students to be self-directed. This should be attributed to the support-fading skill used in the scaffolding. However, to use this skill, the major challenge will be when the support should be faded and how much the support should be reduced at the time. This requires us to find out another technique allowing us to know the learner's mastery level at any point of the scaffolded learning process.

LINKING THE CONCEPT OF SCAFFOLDING TO INTEGRATED-MEDIA DESIGN FEATURES

In this session, we sought for an operational definition of scaffolding. Based on the definition, we proposed a 3-D scaffolding model which provides a systematic way to apply scaffolding in integrated-media based instruction.

The Elements of Scaffolding Relevant to Integrated Media Design

To link the concept of scaffolding to the integrated-media design features, it is important to identify some basic elements of scaffolded instruction which are especially relevant to the integrated-media design. To illustrate the features of those elements, the metaphor of an adult aiding a toddler (Cazden, 1988) will be used as an example.

1. Hierarchical component skills

In the metaphor of scaffolding, the acquisition of skill is conceived as a hierarchical program in which component skills are combined into "higher skills" by appropriate orchestration to meet new, more complex task requirements (Bruner, 1973). Therefore, the crucial task in scaffolding often possesses a variety of relevant components (usually in an appropriate serial order) necessary to achieve a particular end. And that is the instructor's responsibility to decompose the final task into hierarchical component skills based on the nature of the task and the learner's ability. In the example of an adult aiding a toddler, the child must learn how to balance on his feet before taking his first step, must learn how to balance on his first step before stretching out for the second.

2. Decreasing support levels

Scaffolding emphasizes the support that the instructor can provide the learner to reach beyond his/her current skill level. The highest level of support is the situation where the instructor completes the task as a demonstration and the learner takes no responsibility for the current task. The lowest level of support is the situation where the instructor takes no responsibility for the task and the learner completes the task on his/her own. Between the highest and lowest level of support, the instructor shifts a part of the responsibility to the learner by reducing the amount of support one level at a time. In the sense of support withdrawn, the instructor must recognize what kind of support is crucial in the learning and classify the support into decreasing levels. In the example of an adult aiding a toddler, the levels of support could be: helping by holding two hands, helping by holding one hand, helping by holding one finger, etc.

3. Repetitive authentic practice

The scaffolding should be performed in the social context of the practical work environment. In the environment, the learner can practice by taking part in the expert behavior in a realistic setting. Each practice involves a full performance of the task. Besides, the underlying structure of the practice must be repetitive so the experience at one point in task mastery could potentially be applied to later activity. Therefore, the instructor has to set up a sequence of authentic practice involving the performance of the same skills. In the walking example, the child actually experienced the practical task, walking. The practice of walking involves the same component skills and the practice can be repeated in different realistic settings: walking on the carpet, walk on the solid ground, walk on the sand, etc.

4. Ongoing assessment

In the process of scaffolding, the support level should be adjusted based on the learner's current skill level. Therefore, the instructor must measure the learner's progress against the global picture of the task and make corrections when needed. Usually, the completion of each component skill is the right time for a progress assessment. In the walking example, the adult observes and measures the child's progress with each baby step. If holding one hand of the child doesn't keep his balance, the adult gives him the other hand right away. If the child walks well by holding one hand, the adult will consider letting him walk by holding only one finger.

Therefore, an operational definition of scaffolding could be as follows. The instructor or the more skillful peer decomposes the task into hierarchical sub-tasks, classifies the amount of support in decreasing levels, and sets up a repetitive authentic practice. The practice begins with the highest level of support and the lowest level of sub-task. With the completion of each sub-task in the practice, the instructor measures the learner's performance and judges the level of support he/she should provide and lets the learner perfect the component sub-task that he/she can manage.

The Three-Dimension Contingent Scaffolding Model

Wood et al. (1976) and Day and Cordon (1993)'s studies have suggested the "contingent scaffolded instruction", emphasizing the addition of a pattern of responses for the withdrawal of the support. The pattern involves characterizing the instructor's intervention by the level of abstractness and varying those levels systematically in response to the learner's performance. Based on the first two elements of scaffolding discussed above, there are two types of intervention that the instructor can provide in a scaffolded instruction. The first type involves the control of the task complexity by simplifying the task itself. The second type involves the control of the task complexity by providing the additional support. Most studies have focused on the second type of intervention, the additional support. The 3-D model proposed in this session adapted the contingent scaffolded instruction to systematically vary the instructor's support in response to the learner's performance in a learning task consisting of a sequence of steps/sub-tasks.

The first two elements of scaffolding actually divide the learning task into N learning situations. Here N indicates the number of possible combinations of support level and sub-task level. For example, if the target task contains 4 hierarchical sub-tasks and 4 levels of support, there will be 16 different possible learning situation that the learner might encounter at the time depending on the learner's current skill level (see the following figure).

	Support Level 1	Support Level 2	Support Level 3	Support Level 4
Sub-Task 1				
Sub-Task 2				
Sub-Task 3				
Sub-Task 4				

The support levels range from level 1, the least independent and most concrete level (at which the instructor assumes all of the responsibility for the performance) to level 4, the most independent and abstract level (where the learner has assumed most of the responsibility). The sub-tasks range from 1 to 4 representing a sequence of acts which must be completed in this sequence in order to complete the target task. The process of scaffolding starts with the completion of the full task (from sub-task 1 to sub-task 4) at support level 1 and ends with the completion of the full task at support level 4 through a sequence of repetitive authentic practices, the third element of scaffolding. The whole process of scaffolding is performed according to the following rules.

1. Each practice involves a full performance of sub-tasks from the first to the last.

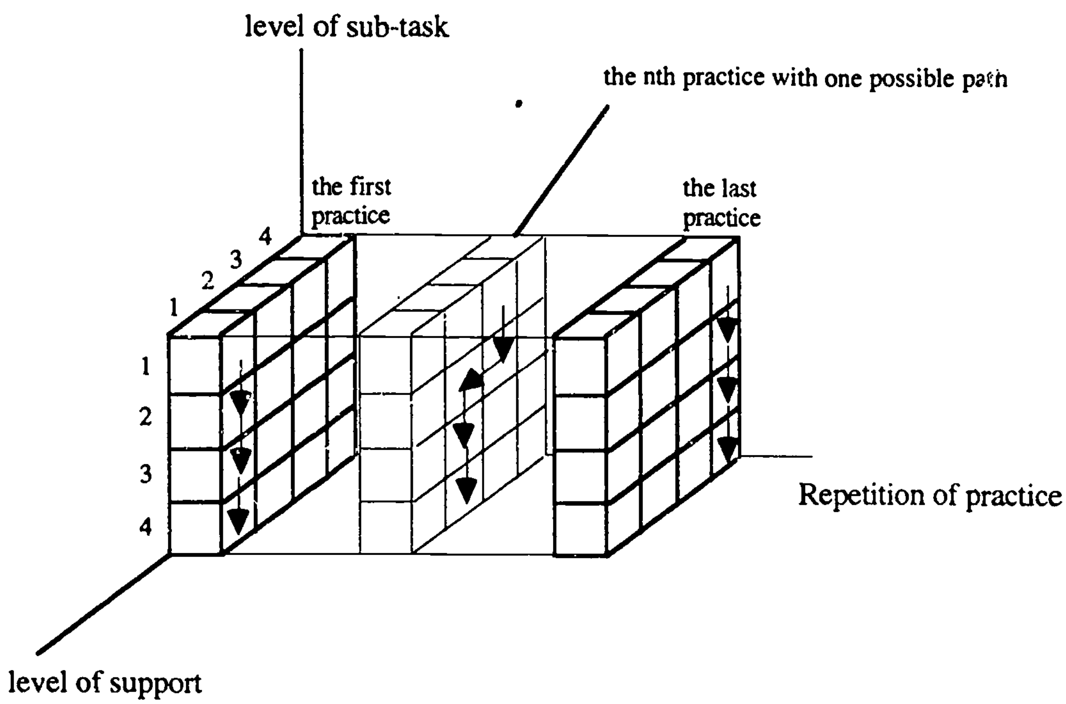
2. The first practice starts with the highest level of support. After that, each practice starts with the level of support which is one level lower than the latest one used in the previous practice.

3. At the current level of support, the learner has the chance to work on the following sub-tasks unless he/she encounters any difficulty.

4. In each sub-task of the practice, if the learner encounters any difficulty, the support level is increased by one until reaching the highest level.

The fourth element of scaffolding, ongoing assessment, is actually embedded in the rule 4. To see if the learner encounters any difficulty, an ongoing assessment must be performed at the end of each sub-task.

This model of scaffolding describes the learning process as a journey in the space of the three dimensions: level of sub-task, level of support, and number of the repetition of the practice (see the following figure). The first practice is presented as an example in which the instructor takes full responsibility for the task (full support is provided). The last practice is a completely successful examination where the learner takes the full responsibility of the task (the least support is provided). Any practice in between either is an unsuccessful performance or a successful performance but with some level of support. Along the path of the journey, each cubic block is a unit of assessment of the learner's progress. Since this model applies scaffolding in a systematic way, it is especially useful for the computer or integrated media based instruction.



AN EXAMPLE OF IMPLEMENTATION: "HYPOTHESIS TESTING-- THE Z-TEST"

Based on the 3-D model, the software, "Hypothesis Testing-- the Z-test", was developed. In this section, we describe the program of "Hypothesis Testing-- the Z-test", and explain how the 3-D scaffolding model was implemented in this program.

The Motivation of the Task

Statistics is interesting and useful because it is a mean of using data to gain insight into real-world problems. However, almost every statistics beginner experiences difficulties understanding the topic. Almost every statistics instructor admits that it is not an easy subject to teach.

As the continuing revolution in computing relieves the burden of calculating and graphing, there is an emerging consensus among statisticians that statistical education should focus on data and on statistical reasoning rather than on either the presentation of as many methods as possible or the mathematical theory of inference (Moore and McCabe, 1993). This consensus has the following influence on statistical education.

1. Applied Statistics should be taught in the context of real-world problems.
   Statistics takes real life patterns in real life phenomena and tests them quantitatively. Bridging that gap between reality and numbers is the hardest part. Not all numbers are data. The number 10.3 acquires meaning only when we are told that it is the birth weight of a child in pounds or the percent of teenagers who are unemployed. That is the context that makes the numbers meaningful. Therefore, the examples and exercises should be presented in the context of real-world problems.

2. Applied Statistics can be taught to an extremely diversified audience.
   Because the statistics is useful for scientific investigators in many fields, the students sitting in a introduction course of applied statistics might have varied background in Agriculture, Biology, Chemistry, Computer Sciences, Education, Engineering, Genetics, Home Economics, Industrial Management, Mathematics, Medicine, Pharmacy, Social Sciences, Statistics and Veterinary Science. However, if the student has no fear of statistics, wants to learn and possesses a certain amount of mathematical maturity, the varied backgrounds need not detract from the success of the course. In fact, many times this diversity may make students recognize similarities among problems from different fields of application. This gives them a broader scientific approach to statistical problems than providing them only with familiar examples.

3. Applied Statistics can be taught at a low mathematical level.
   Since it is the statistical reasoning that should be focused upon instead of the statistical computation, even students with low mathematical level can learn statistics. Therefore, the students of applied statistics can range in mathematical competence from Ph.D. candidates in mathematics to students who had only high school algebra. Actually, the learners need only a working knowiedge of algebra. Being able to read and use formulas would be enough.

4. Applied Statistics can be taught through the applications of a set or a sequence of rules.
   Applied Statistics is actually the application of a sequence of rules or principles which is set up based on certain mathematical proofs or the experience of prior statistical experts. The learners do not have to understand the mathematical proof behind each rule. However, it is important for them to understand the expert reasoning behind those rules. It is not only logical but also conceptual. To understand the statistical reasoning, the learner has to work and communicate with the expert to carry out the rules in realistic problems.

Based on the above discussions, we decided to develop a scaffolded computer based instruction in the context of teaching basic applied statistics. The very basic test of statistic hypothesis testing-- the Z-test was selected. The task was selected with several objectives in mind. First, it had to be challenging to the learner while also proving sufficiently complex to ensure that his/her comprehension and problem-solving skill over time could develop. Second, it had to be "feature rich" in the sense of possessing a variety of relevant components. Third, its underlying structure had to be repetitive so the experience at one point in task mastery could potentially be applied to later activity.

This subject matter involves a sequence of problem solving steps and decision making. It naturally provides the chance for assessing users' ongoing learning as well as scaffolding through program support. Therefore, the program instruction is presented as a series of problems involving applying the Z-test.

Implementing the 3-D Contingent Scaffolding Model in "Hypothesis Testing-- the Z-Test"

The following table summarizes the four elements of the scaffolding model and briefly describes how each is implemented.

Elements of Scaffolding and "Hypothesis Testing-- the Z-Test" CAI Design Features

Elements of Scaffolding	CAI Design Features
1. Hierarchical component skills	Four serial steps to carry out the Z-test
2. Decreasing support levels	Four levels of support
3. Repetitive authentic practice	Up to 20 authentic problem scenarios
4. Ongoing assessment	Performance is judged at the end of each step

1. Hierarchical component skills

The common practice of hypothesis testing includes of the following steps.

a. State the hypotheses;
b. Find the critical value;
c. Compute the test statistic; and
d. Make the decision.

Based on the four steps, the program decomposes the task into four sub-tasks, allowing the learner concentrate all his/her effort on one sub-task at a time.

2. Decreasing support levels

In considering the support which can be provided via integrated-media and the nature of the task, three types of support were selected to be used in the scaffolded instruction. From concrete to abstract, the three types of support are:

a. Visual Support

This is a graphic illustration of the problem situation. Usually, the graph consists of one or two bell-shape curves, representing the sampling distribution(s) involved in the current step situation. This kind of graphic illustration has been used extensively in the statistics textbooks and statistics classrooms when the topic of hypothesis testing is first introduced. Most of the statistics teachers and learners believe this kind of visual support may facilitate statistical reasoning. In this program, this kind of graphic illustration was used as a visual hint to the answer of the current problem step.

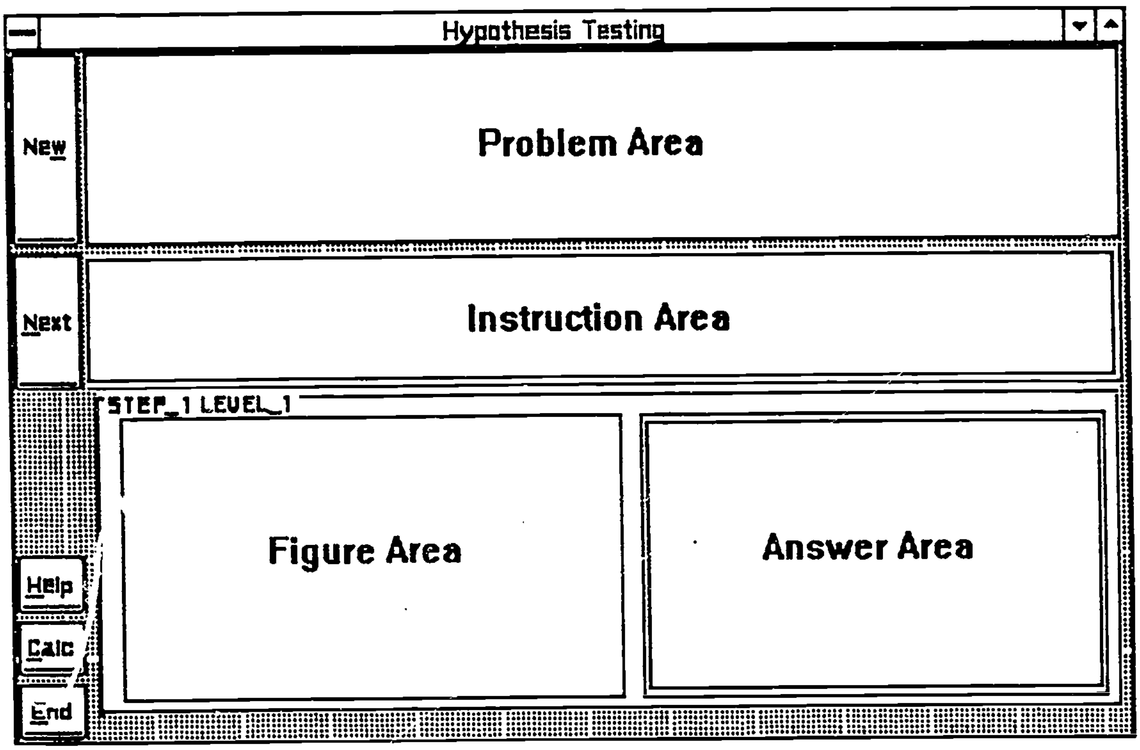
b. Verbal Support

This type of support includes the text instruction and leading questions or hints shown on the screen. While the answer of the current step is provided by the computer tutor, the verbal support is an explanation of the answer. While the answer should be provided by the learner, the verbal support is a hint and leading question of the answer of the current problem step. For example, "The first step of the hypothesis testing is to state the Null and Alternative Hypotheses. What hypotheses can you state for this problem?"

c. Symbolic Support

This type of support could be a specific Greek/English letter with a pre-defined meaning or a mathematical symbol for operations. Having the statistical reasoning, the practice of statistics can always be represented by formula, symbols, and numbers. The four steps of the hypothesis testing can also be represented in symbols. In practice, the symbolic support took the form of a symbolic prompt, requesting the learner to provide the answer of the current problem step. For example, "Z_a =" prompts the learner to find the critical value of the test statistic Z using the given level of significance a.

The program was developed using Visual BASIC 3.0 for the Windows environment. The actual environment of the lesson is displayed in the following figure. It explains how the visual, verbal, and symbolic support show on the program screen.



The environment of the lesson.

1. Problem Area
The Problem Area shows the current problem scenario that the student is working on.

2. Instruction Area
The Instruction Area provides the instruction or hints to solve the current step of the problem. It counts as the verbal support.

3. Figure Area
The Figure Area illustrates the current step situation of the problem in a graphic form based on the learner's selection of the answers. That is where the visual support takes place.

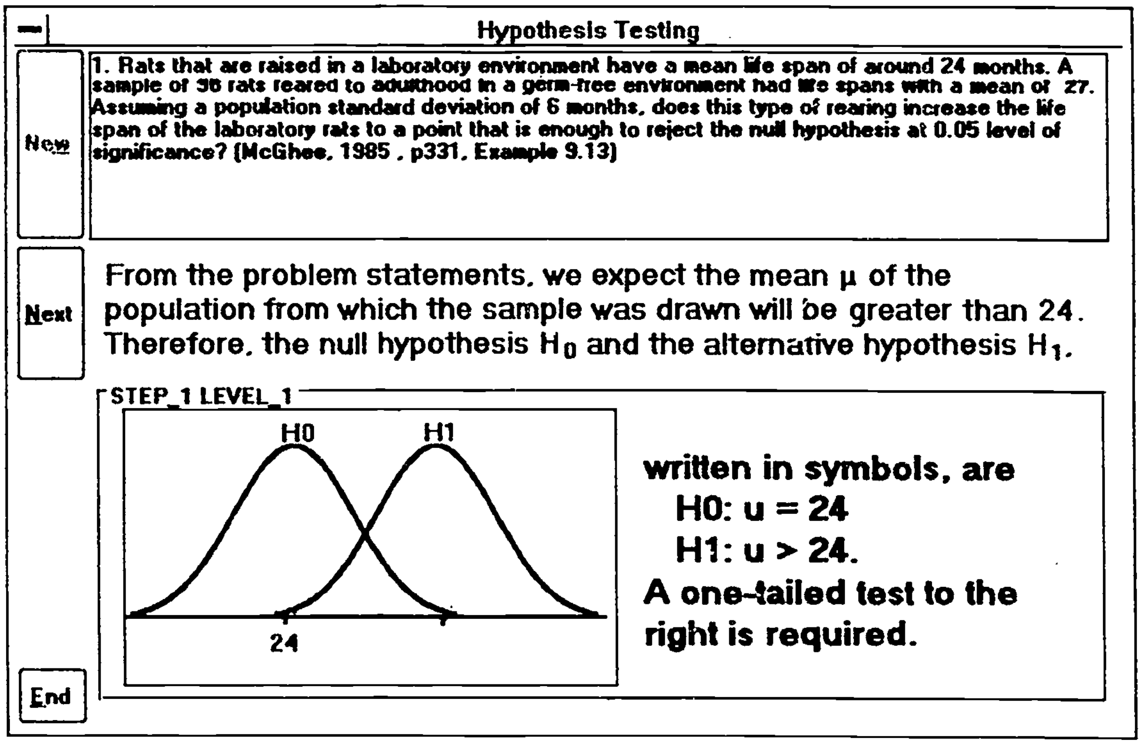
4. Answer Area
The Answer Area provides the answer or requests the learner to provide answer for the current step after the symbolic support.

Levels of Program Support

Based on the three types of support described above, the levels of support can be classified and ranked by the amount of support (how many types of support) provided at the time. These are described below. From level 1 to level 4, the next most concrete type of support is withdrawn from the previous level of support.

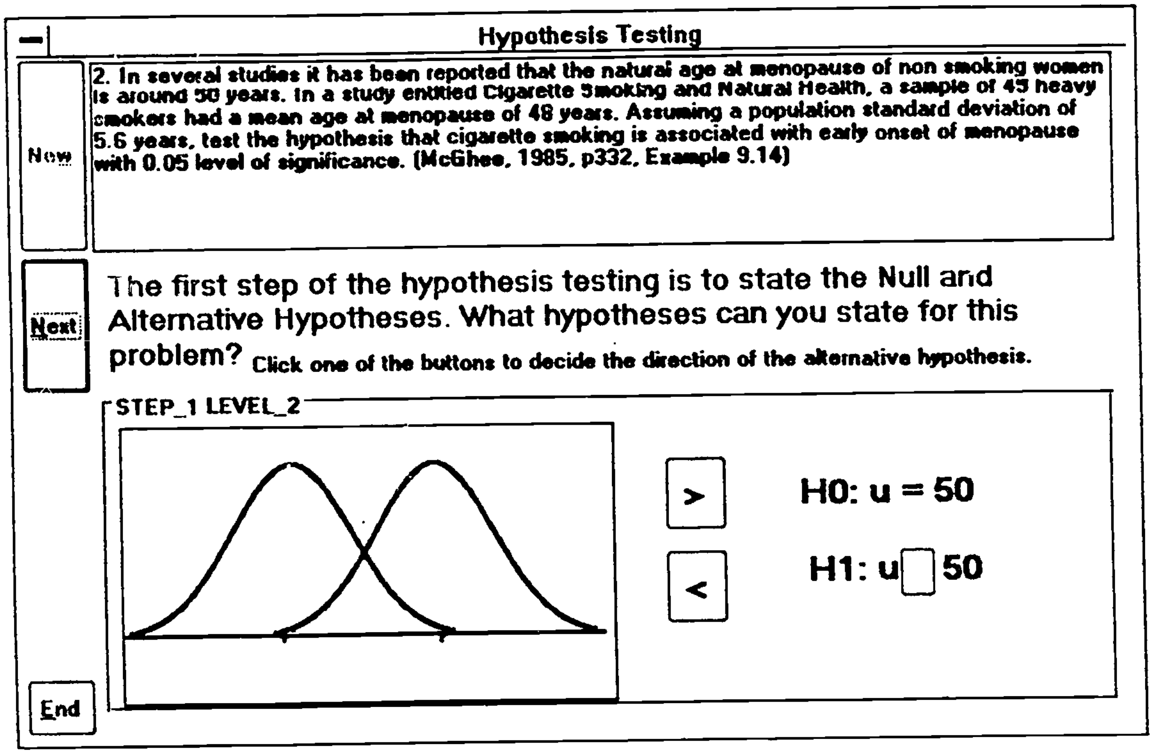
Level 1: *Full Support*

The instruction demonstrates the steps to solve the problem in detail with visual, verbal, and symbolic information. The following is an example of the full support screen.

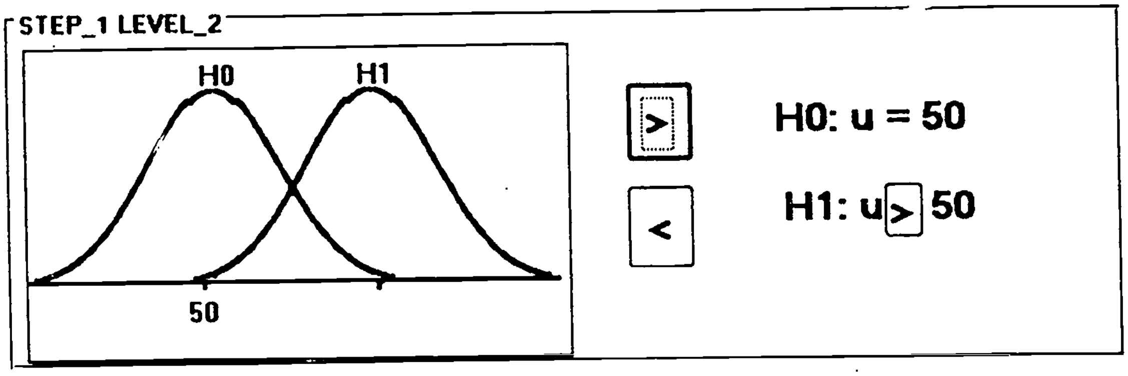


Level 2: *Visual, Verbal, and Symbolic Support*

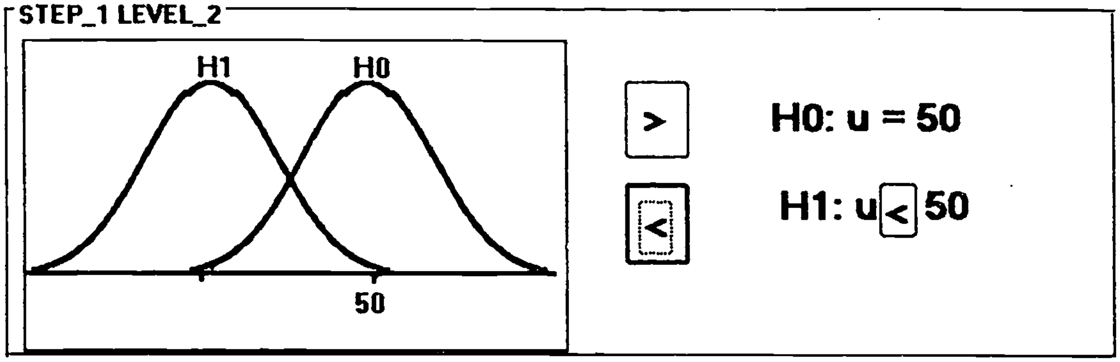
Instead of providing the answer with detailed explanation, the instruction only provide the visual and verbal hints to the current problem step and requests the learner to give the answer after the symbolic prompts. An example of the screen with level 2 support is provided in the following figure.



The Figure Area in the example is an initial form of the graphic illustration of the current step, Step 1. Based on the learner's selection of the answers, more information will be added to the graph. The following figure shows the result if the ">" is selected in the answer area.

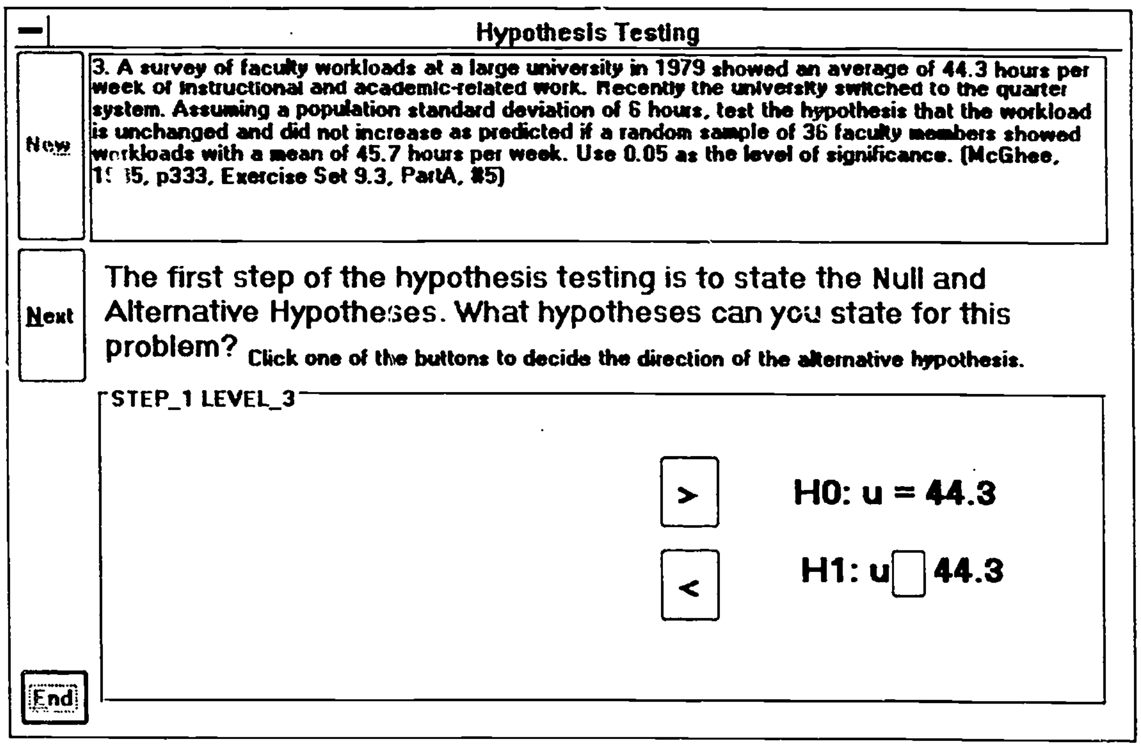


On the other hand, if the "<" is selected, the result will be:



Level 3: *Verbal and Symbolic Support*

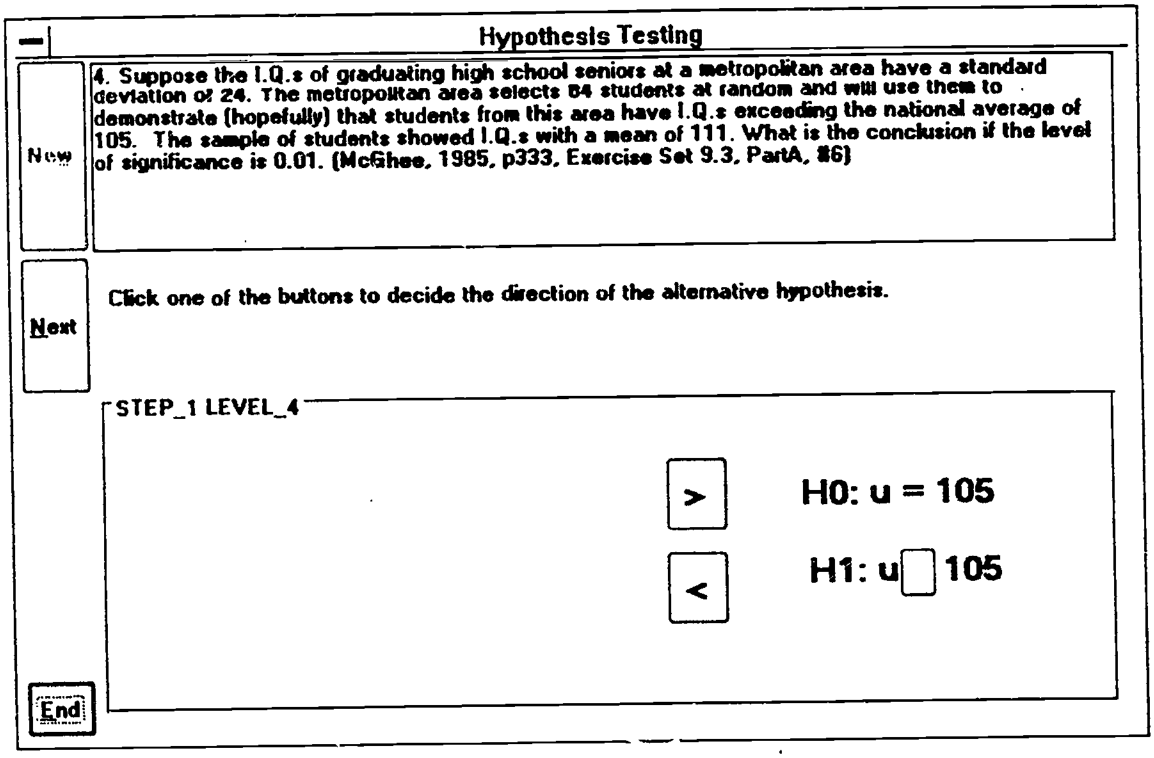
The information in the figure area disappears. Only the verbal hint is provided, telling the learner some specific information to look for and asking him/her to provide answers after the symbolic prompts. The following figure is an example screen with this level of support.



The visual hints of the current step have been taken away.

Level 4: *Symbolic Support*

The instruction takes away the next most concrete support from the screen. Therefore, only the symbolic prompts will be provided, requiring the learner to give answers. The following screen shows the problem step 1 with least level of the support.



Not only has the visual support been taken away, the verbal hints are no longer shown on the screen either.

The combination of the 4 component steps of the task and the 4 levels of the support makes 16 possible learning situations:

	LEVEL 1: Full Support	LEVEL 2: Visual, Verbal, & Symbolic Support	LEVEL 3: Verbal & Symbolic Support	LEVEL 4: Symbolic Support
STEP 1: State the Hypotheses				
STEP 2: Find the Critical Value				
STEP 3: Compute the Test Statistic				
STEP 4: Make the Decision				

Based on the 16 learning situations, 16 templates of the information screens were created in the program.

13

3. Repetitive authentic practice

The problems were adapted from examples in statistics text books, covering the real problems in many disciplines: agriculture, biology, engineering, pharmacy, business, and the social sciences.

4. Ongoing assessment

At the end of each step, the learner's answer is judged for correctness. This judgment decides the next learning situation the learner will encounter.

Recall the navigation rules of the 3-D learning journey described in the previous section:

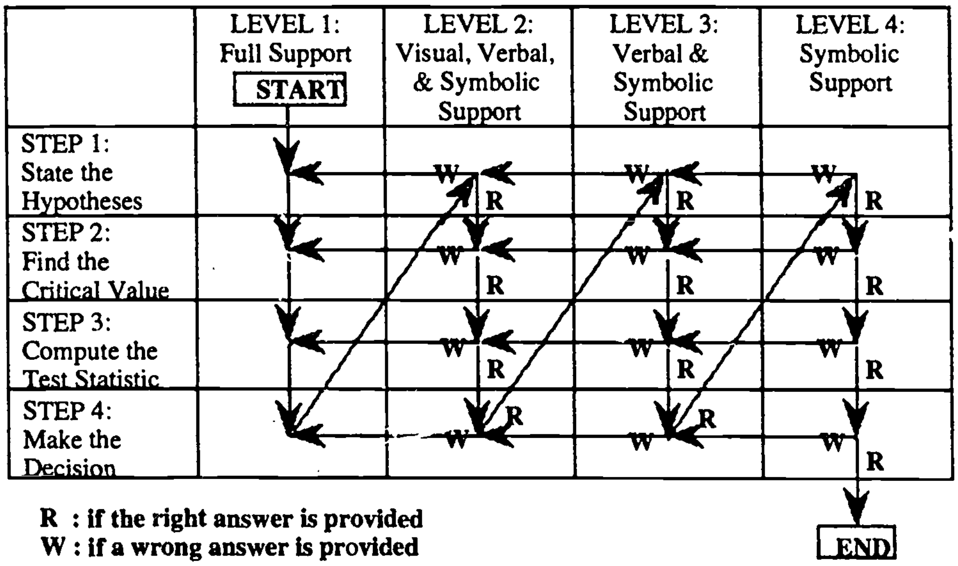
1. Each practice involves a full performance of steps 1 to 4;

2. The first practice starts with the highest level of support-- Level 1. After that, each practice starts with the level of support which is one level lower than the latest one used in the previous practice;

3. At the current level of support, the learner has the chance to work on the following sub-tasks unless he/she encounters any difficulty.

4. In each step of the practice, if the learner encounters any difficulty, the support level is increased by one until reaching the highest level-- Level 1.

If we project all the possible 3 dimensional learning journeys on to the 2 dimensional table of the 16 learning situations, the possible learning paths are:



We believe this model provides a systematic way to integrate the method of scaffolding and the integrated-media based instruction. Because this model not only bridges the learner's skill levels but also effectively withdraws support, the learner can finally become an active and independent learner. Therefore, this specific scaffolded computer-based instruction, "Hypothesis Testing-- the Z test", was expected to be an effective and powerful instructional program, inheriting the advantages and minimizing the limitations of scaffolding. In this study, this scaffolded instruction was evaluated in terms of comprehension, knowledge maintenance, and knowledge transfer by comparing it to the full-support instruction (in which the full support is available all the time), and the least-support instruction (in which only the symbolic support is provided, prompting for the answers).

EVALUATION OF "HYPOTHESIS TESTING-- THE Z-TEST"

"Hypothesis Testing-- the Z-Test" has been evaluated to address three major questions and corresponding hypotheses:

- Would the availability of full support in the computer-assisted learning hamper learner's independence? Our hypothesis was that the students in the full support condition would not perform better than the students in the least support condition (the control condition) in the maintenance and transfer posttests, where the support was no longer available.

- Would scaffolded instruction enhance knowledge maintenance in a computer-assisted learning environment? Our hypothesis was that students in the scaffolded condition would perform better in the maintenance posttest than students in the other two conditions.

- Would scaffolded instruction promote knowledge transfer in a computer-assisted learning environment? Our hypothesis was that students in the scaffolded condition would perform better in the transfer posttest than students in the other two conditions.

A secondary interest was about the subject matter itself.

- Could the subject of "Hypothesis Testing" be taught at low mathematical level? Our hypothesis was that students with low mathematical skills would also benefit from this scaffolded instruction.

The Experiment

Research Design

Based on the research questions and hypothesis described above, a baseline-posttest control group design was implemented using the computer program, "Hypothesis Testing-- the Z-test". All the hypotheses were analyzed under a regression model.

Regressor Variables

There were two types of regressor variables considered in this study.

1. Baseline Variables

The learner's mathematical and statistical background was measured from six different aspects. They were: courses taken in Mathematics (MATH_C), courses taken in Statistics (STAT_C), self-rating mathematical skills (MATH_S), self-rating statistical skills (STAT_S), mathematics preference (MATH_P), and statistics preference (STAT_P).

Besides, the pretest score was also collected as a baseline measure of their prior knowledge about the topic to be taught.

2. Treatment Variable-- the support condition

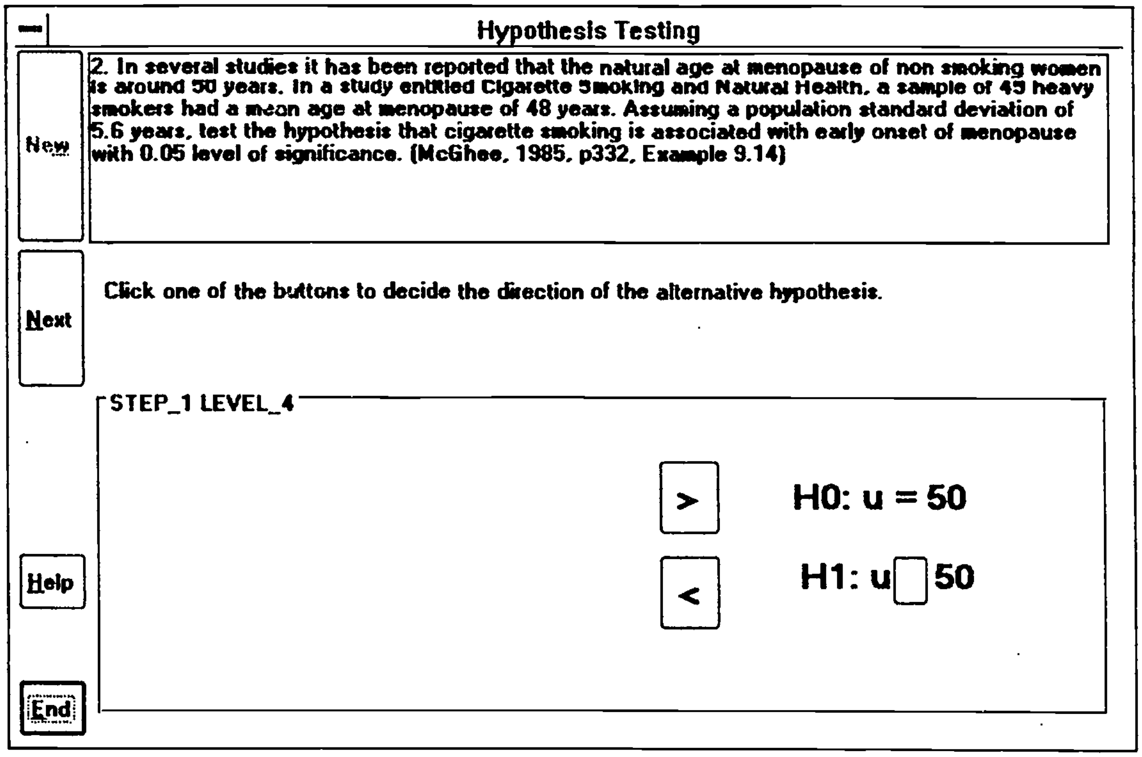
To test the effectiveness of the scaffolded instruction, the full support and the least support versions of "Hypothesis Testing-- the Z-Test" were also created. The three different instructional conditions are described below.

Scaffolded Condition (adjusts level of support among 1, 2, 3, and 4 in an orderly fashion depending on the learner's current ability)

Based on the four levels of support, the program started from the level of full support. The amount of support was reduced by one level in the next problem as the user demonstrated the ability to solve the present problem at the current level of support. Once the user encountered difficulty at any step of the problem-solving process, the amount of the support would be increased by one level for the current problem step immediately. The teaching process proceeded until the user could solve two consecutive problems with the lowest level of support.

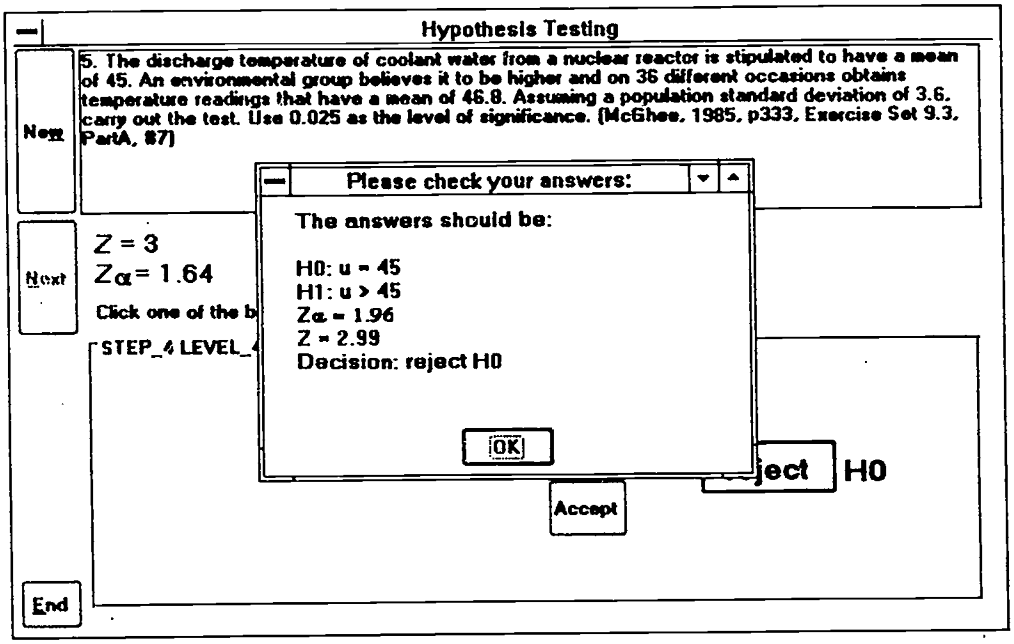
Full Support Condition (swing between levels of support 1 and 4)

This condition represents the support condition which has been used in many computer-assisted learning environments. The program first demonstrated the complete problem solving procedure in a full-support example. Then it gave another problem with the least amount of support (i.e. symbolic support) as a test. Full support was a screen option which can provide immediate help if the user encountered any difficulty in the problem-solving process (see the following figure). If the user did not ask for full support but made any mistake in any step of the problem solving procedure, the full support would be provided starting from the current problem step. The current problem would then be solved as an example and the next problem would be presented with the least level of support as a test again. That is, the program support swung between the levels of full support and least support. The teaching process proceeded until the user could solve two consecutive problems with the least amount of support.



Least Support Condition (use level of support 1 once, then level of support 4 for the rest)

This condition of program support represents the traditional teaching method which has been used in many statistic textbooks. It served as a control condition. As in the other two treatment groups, the program first explained the four steps of hypothesis testing procedure in a sample Z-test problem thoroughly (i.e. with full support). However, in the following problems, only the least amount of support (i.e. symbolic support) was provided. The user's response in each step was judged for correctness at the end of each problem. If any mistake occurred in any step of the solving procedure, the correct answers would be provided without explanation (see the following figure). The process proceeded until the user solved two consecutive problems.



All conditions of the instructional program accessed the problems from a data file which contained 20 problems involving Z-test about one-tailed single sample mean.

Response Variables

Two response variables were involved in this study. They were students' scores on the maintenance posttest and transfer posttest.

Subjects

Subjects were 72 students enrolled in an introductory course of educational psychology at Purdue university in the Fall semester of 1995. The majority of the students were juniors and sophomores in educational majors.

Before their participation, the concepts of the normal distribution, standard deviation, and the Z-score had been covered in the first 6 weeks of the course. Therefore, the materials of instructional program were relevant and appropriate to the students.

The participation of the study was counted as two-hour research credits. Students were invited on a volunteer basis. Subjects were then randomly assigned into the three condition groups.

Instruments

All the tests were administered in paper-and-pencil format with a calculator and a copy of the Z-score table provided.

Pretest and Maintenance Posttest

Each test consisted of three problems involving a one-tailed Z-test of single sample means. Each problem consisted of four steps and each step involves at least three different subconcepts. Therefore, a total score of 48 was possible.

Transfer Posttest

It contained one one-tailed and two two-tailed Z-test problems of single sample means. Each problem consisted of four steps and each step involves at least three different subconcepts. Therefore, a total score of 48 was possible.

All the test problems were adapted from statistic textbooks and previewed by two experts in statistics.

Procedure

The experiment was conducted in the seventh to tenth weeks of the Fall semester of 1995. It consisted of two sessions with 7 to 10 days in between. For better control of the experiment, the first session was conducted by one of the researchers, one student at a time.

Session One

The participant first completed a participant survey at the beginning of the first session of the experiment. Then the participant was informed of the session agenda and the expected time spent on each activity. After that, the researcher checked the participant's mouse skill and demonstrated the skill if necessary. Before working on the computer, the participant was provided with a simple, hand-held calculator, a Z-score table, and a couple of worksheets for notetaking and calculation. The participant could keep and use these tools for the rest of the session. The participant then started to work on the pre-instruction in front of the computer for about 20 minutes. The pre-instruction covered all the prerequisite skills needed for the major instruction. Then, for 10 minutes, the participant had a chance to self-evaluate the key concepts learned in the pre-instruction by working on the paper-and-pencil prerequisite test. A key with detailed explanation was provided. After the prerequisite test, the participant was given a three-problem pretest to work on. The participant was told at the beginning that he/she was not expected to know the answers to these problems. If having spent more than three minutes on one problem but was unable to proceed, he/she could quit the pretest there. The expected time for the pretest was 10 minutes. After completing the pretest, the participant went back to the computer screen and work on the major instruction for 45 minutes. The instruction started with a short introduction of the lesson environment. After that, the program demonstrated a step by step procedure to carry out the Z-test in a problem example. Then the participant encountered a series of similar problems requiring him/her to provide the answers step by step. Along with these problems, one of the program support conditions (scaffolded, full support, or least support) was applied, depending on which condition group the participant had been assigned into. The program could not be terminated until the participant solved two consecutive problems with the least amount of support. However, the researcher would ask the participant to stop if he/she had spent more than 45 minutes on the major instruction and not finished. During the instruction, the participant could either use the computer and the Z-score table at hand or the ones on the computer screen. The participant's learning path and responses were recorded in an output file. The number of problems the participant went through either to mastery or by reaching the time limit was noted.

Session Two

This session was held about 7 to 10 days after the instruction session. The subject first was asked to complete the three-problem maintenance posttest for 20 minutes. After the test, a one-page instruction on two-tailed Z-test was provided. After 10 minutes, the instruction sheet was taken away and the three-problem near transfer posttest was administered. Again, the subjects could work on the test for 20 minutes. Upon completion of the test, the solutions to all the test problems were provided to the subject.

Data Analysis and Results

One-way ANOVA was first conducted on pretest to establish pre-study equivalence. Then, regression analysis was applied to both response variables (Maintenance Posttest and Transfer Posttest) with the eight regressor variables (Support Condition, Pretest, MATH_C, STAT_C, MATH_S, STAT_S, MATH_P, and STAT_P).

Pretest

The following table shows the results of the test for the group difference on pretest.

Group	Sample Size	Mean	Std Dev	F Value	Pr > F
Full Support	24	4.25	5.28	0.59	0.5554
Scaffolded	26	4.26	3.68		
Least Support	22	5.54	4.81		

All the three groups got low average scores on pretest. No significant difference was found among groups.

Maintenance Posttest

The sample -ize, mean, standard deviation, and the least square mean on maintenance posttest for each treatment group (support condition) are listed in the following table.

Support Condition	Sample Size	Mean	Standard Deviation	Least Square Mean
Full Support	24	22.20	13.23	21.43
Scaffolded	26	26.92	11.98	28.19
Least Support	22	19.70	12.29	19.07

The treatment effect on maintenance posttest was examined in the regression analysis along with other regressor variables. The following table presents a summary of the significance data for regression analysis on the maintenance posttest.

Response Variable: Maintenance Posttest

Source	F Value	Pr > F
Model (R-Square = 0.388188)	4.37	0.0002
Support Condition	2.89	0.0227
Pretest	6.53	0.0130

The data from this analysis showed significant effects for the treatment variable-- the support condition and the pretest. The effects of the rest of the regressor variables were not significant at 0.05 level of significance. Pairwise t-tests were conducted on the support condition as a post hoc analysis. The following table presents the results.

Support Condition	Full Support	Scaffolded	Least Support
Full Support	-	t = -2.05 p = 0.0442	t = 0.73 p = 0.4648
Scaffolded	t = 2.05 p = 0.0442	-	t = 2.75 p = 0.0078
Least Support	t = -0.73 p = 0.4648	t = -2.75 p = 0.0078	-

The least square mean score of the scaffolded group was significant higher than the other two groups at 0.05 level of significance. No significant difference were found between the full support group and the least support group.

Transfer Posttest

The sample size, mean, standard deviation, and the least square mean on transfer posttest for each treatment group (support condition) are listed in the following table.

Support Condition	Sample Size	Mean	Standard Deviation	Least Square Mean
Full Support	24	25.39	15.54	26.50
Scaffolded	26	30.98	10.15	29.58
Least Support	22	27.50	13.22	27.94

The treatment effect on transfer posttest was examined in the regression analysis along with other regressor variables. The following table shows the significant results of regression analysis on the transfer posttest.

Response Variable: Transfer Posttest

Source	F Value	Pr > F
Model (R-Square = 0.376209)	4.15	0.0003
Pretest	6.36	0.0143
STAT_C	4.76	0.0329
MATH_S	6.97	0.0105

The preceding data suggested that the transfer posttest score was significantly influenced by the pretest score, the statistics courses taken before, and the learner's self-rating mathematical skill. The effects of the rest of the regressor variables were not significant at 0.05 level of significance, including the treatment effect (the support condition).

Discussion

Maintenance Posttest

The Support Condition

The results support our first hypothesis. The students in the full support condition did not perform significantly better than the control group (i.e. the least support group). The availability of full support in the program, "Hypothesis Test-- the Z-Test", did hamper learner's independence. On the other hand, the results indicate that the scaffolded instruction was quite successful in this study. The scaffolded group got significantly higher average score than the other two groups. Our second hypothesis was also verified.

This finding is consistent to the suggestion proposed by the Cognition and Technology Group at Vanderbilt University (1993). To avoid the learner over relying on the support provided in the integrated media, its designs should function to provide scaffolding rather than always provide full support.

Pretest Score

It is not surprising that the students' performance on maintenance posttest was influenced by their prior knowledge on the topic. Actually, the results also shows that most of the students did not have any prior knowledge on the target learning task (applying the Z-test) except the very basic statistic concepts taught in the introductory course (such as normal distribution and standard deviation). However, the understanding of these very basic concepts (which was reflected on the pretest score) might improve the learner's statistical reasoning on the learning task (which was reflected on the posttest scores). Basically, the background of this subject group was very homogeneous. No significant differences were found among the three treatment groups.

Other Baseline Measures on Learners' Mathematical and Statistical Background

The results show no significant effect for any of these baseline variables. The finding on learners' mathematical background supports our last hypothesis. Since the maintenance posttest score was not affected by the learner's mathematical background, students with low mathematical skills would also benefit from this scaffolded instruction. Only 4 to 6 students in each group had ever taken Statistics course before. The finding of no significant effects of learners' statistical background also shows that the content can be taught to statistical beginners.

Transfer Posttest

The Support Condition

The findings failed to support our third hypothesis. The transfer posttest score was not significantly influenced by the support condition. There are four possible explanations:

1. The two-tailed tests on the transfer instrument actually involved the same four steps as the one-tailed tests. The one page example of a two-tailed case gave the learner a chance to review and recall the four steps.

2. Instead of showing one step at a time on the screen, the one page example presented the four steps all together on the same page. It have given the learner a whole view of the statistical reasoning.

3. The two-tailed tests did not involve deciding the direction of the alternative hypothesis. However, that's the most crucial concept in the one-tailed tests. Many students expressed that the two-tailed cases were easier than the one-tailed cases.

4. The treatment condition may promote immediate learning but not transfer.

Therefore, most of the learners got a higher score on the transfer posttest. Although the group difference on transfer posttest did not reach the significant level, the scaffolded group still got a higher average score and a smaller standard deviation than the other two groups. One interesting finding was that the least support group got a higher mean score and a smaller standard deviation than the full support group. This might be explained by the least support group having a higher pretest score or the least support group actually needed to spent more mental effort to carry out the test on their own.

The Pretest

The effect of the pretest also was apparent on the transfer posttest. This result was expected.

Other Baseline Measures on Learners' Mathematical and Statistical Background

Only the courses taken in Statistics (weighted by the course level) and the self-rating mathematical skills (on a scale of 10) showed significant effects for the transfer posttest score. This result suggests that students having more statistical background, feeling more confident about their mathematical skills transferred the old skill to the new learning situation better.

CONCLUSIONS

In this paper, the 3-D contingent scaffolding model has been discussed, implemented, and evaluated on a computer-based instruction, "Hypothesis Testing-- the Z-Test" in order to establish baseline data for integrated-media-based instruction and hypermedia based learning environment. The results indicate that this model can be successful in promoting learning. This model provides a systematic way to link the concept of scaffolding to the integrated media design features using both support building and fading techniques. It could be adapted to other integrated media learning environments and for other content and other audiences.

REFERENCES

Boyle, O. F. & Peregoy, S. F. (1990). Literacy scaffolds: Strategies for first- and second-language readers and writers. The Reading Teacher, 44(3), 194-200.

Bruner, J. (1983). Child's talk: Learning to use language. New York: W. W. Norton.

Cazden, C. B. (1988). Classroom discourse: The language of teaching and learning. Portsmouth, NH: Heinemann.

Cognition and Technology Group at Vanderbilt (1993). Integrated media: Toward a theoretical framework for utilizing their potential. Journal of Special Education Technology. 12, 71-85.

Day, J. D., & Cordon, L. A. (1993). Static and dynamic measures of ability: An experimental comparison. Journal of Educational Psychology, 85, 75-82.

Dyson, A. H. (1990). Weaving possibilities: Rethinking metaphors for early literacy development. The Reading Teacher, 44(3), 202-213.

Gaffney, J. S., & Anderson, R. C. (1991). Two-tiered scaffolding: Congruent processes of teaching and learning. In E. H. Hiebert (Ed.), Literacy for a diverse society: Perspectives, programs and policies. NY: Teachers College Press.

Gallimore, R., Tharp, R., & Rueda, R. (1989). The social context of cognitive functioning in the lives of mildly handicapped persons. In D. A. Sugden (Ed.), Cognitive approaches in special education (pp. 51-82). Lewes: Falmer Press.

Greenfield, P. M. (1984). A theory of the teacher in the learning activities of everyday life. In B. Rogoff & J. Lave (Eds.), Everyday cognition, Cambridge, MA: Harvard University Press.

Jackson, S. L., Stratford, S. J., Krajcik, J., Soloway, E. (1995). Learner-centered software design to support students building models. Paper presented at the 1995 AERA Annual Meeting, San Francisco.

Lieberman, D. A. ,and Linn, M. C. (1991). Learning to learn revisited: Computers and the development of self-directed learning skills. Journal of Research on Computing in Education, 23(3), 373-395.

Moore, D. S., & McCabe, G. P. (1993). Introduction to the practice of statistics. New York: Freeman.

Steiner, K. E., Moher, T. G. (1994). Scaffolding story construction with interactive multimedia. Journal of Educational Multimedia and Hypermedia, 3, 173-195.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17, 89-100.