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ABSTRACT

The Stanford Computer-Based Educator Training Intervention (SCETI) was designed to provide teachers with extensive instruction in cardiovascular disease risk factor concepts and to assess the intervention's effects on a number of teacher variables mediating program implementation. The SCETI program was an interactive computer program which used principles of programed instruction to guide the user through units on coronary heart disease, exercise, nutrition, smoking, and stress. Six teachers completed the SCETI program while nine teachers participated in a half-day training workshop. Results indicate that exposure to the programed instruction-based SCETI program resulted in significant knowledge gains. The computer-assisted condition resulted in teachers learning significantly more than teachers in the workshop group. Four of the five computer-assisted instruction units were influential in the modification of self-reported teacher health behaviors. Self-reported data from SCETI teachers suggest that the methodology employed in the development and delivery of the SCETI program alleviated many teacher concerns, increased teacher comfort with and enthusiasm for the program, and enhanced teacher preparedness to deliver the program. (Contains 38 references.) (JDD)

Toward Effective Program Implementation: The Stanford Computer-Based Educator Training Intervention (SCETI)

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Introduction

The Need for Research on the Diffusion of School-Based Health Promotion Programs

School-based health promotion/disease prevention is a growing field.[1] To date, most school-based health promotion/disease prevention studies have appropriately attempted to determine whether prevention programs are efficacious when implemented under relatively standardized, well-controlled conditions. Only recently have investigators begun to study the effects of prevention programs under "real world" conditions.[2-5] As yet, little information is available to assess large-scale diffusion of prevention programs from research settings to school environments.[6] Importantly, little is known about the extent to which teachers will implement prevention programs on their own, and how implementation might be enhanced. Recently, a number of researchers and health policy makers have urged prevention researchers to turn their attention to such questions, in an effort to achieve widespread diffusion of effective health promotion or disease prevention programs. [1, 6-8]

The Need for Program Implementation Research

Diffusion is defined as the spread of new knowledge to a defined population, over time, through specific channels. Ideas, practices, or objects that are perceived as new by units of adoption are referred to as innovations.[9] The diffusion of innovative school-based health promotion programs has been described as a four-stage process. [6, 10-11] The first stage is dissemination, in which school districts are made aware of programs and encouraged to adopt them. The second stage is adoption, in which districts make a commitment to initiate a program. The third stage, implementation, occurs when teachers or other appropriate personnel deliver the program. The final stage is curriculum maintenance, in which school administrators and teachers continue faithful use of the program.

Research on diffusion has focused on the first two stages in the diffusion process: adoption and dissemination. Considerably less effort has been devoted to determining whether and how innovations get used in classrooms.[12] The assumption has often been made that adoption at the organizational level — school or school district — results in adoption and implementation at the teacher level. Yet failure to plan for effective implementation is often the major reason new programs fail.[13] Thus, it is critical that systems for diffusion of educational innovations pay close attention to issues of implementation and maintenance if long-term impacts on students are to be achieved.[14]

Determinants of Program Implementation

A variety of organizational and individual (i.e., teacher) variables have proved to be effective in predicting implementation of innovative programs. Organizational factors that are positively correlated with implementation include strong teacher morale, a high degree of teacher involvement in decision making, active support of school principals, general support of district superintendents for the innovation, and a good fit between the innovation and local needs.[15-17]

At the program provider level, adoption and implementation of innovative programs are related to attributes of the innovation as well as cognitive, social, and psychological attributes of the providers themselves. Classroom teachers are most likely to implement educational innovations that are well specified and require the same teaching strategies they normally use. Other teacher variables mediating program implementation include the teacher's enthusiasm, preparedness, comfort with and acceptance of the curriculum, and confidence in their ability to implement the curriculum effectively. For example, one study found that intention to continue teaching an

innovative sex education course after the first year of implementation was positively associated with comfort with the content and approach of the program, and positive attitudes towards it.[18] Recent studies of smoking prevention program facilitators, who are not regular classroom teachers, have shown that program integrity is positively associated with an enthusiastic, confident, and non authoritarian teaching style[19] and characteristics such as being outgoing, adventurous and organized.[20]

The Importance of Teacher Training for Effective Program Implementation

Implementation interventions are designed to equip staff with the knowledge, skills and resource support necessary to conduct a new program such that all program components are included and there is fidelity to the content of the program.[13] One factor that appears to be critical to effective program implementation is teacher training. It has been shown that for curriculum innovations in general, and school health innovations in particular, the provision of pre-implementation training increases the likelihood that teachers will implement the curriculum fully and with integrity.[15-16, 21-23] Training may be especially important to prepare teachers to implement psycho-social-based prevention programs because they tend to employ teaching methods that differ from traditional lecture and discussion formats.

Study Objectives

In a previous study we developed and evaluated an Adolescent Heart Health risk reduction curriculum for high school students. When delivered by specially trained health educators, the curriculum demonstrated significant effects across a number of variables, including: (1) increased student knowledge of cardiovascular disease (CVD) risk factors, (2) reduction of experimental smoking, (3) reduction of body fatness, (4) reduction of resting heart rate, and (5) increase in physical activity levels.[24] Having produced an effective curriculum we next turned to the question of program diffusion using regular school teachers. We chose to de-emphasize the dissemination and adoption stages since the participating school district had already mandated that the program be taught as part of the regular physical education (PE) curriculum, the project had the firm support of the PE department heads, and principals and regular teaching staff had been actively involved in the decision to deliver the program to students.

Rather, we decided to focus on factors thought to enhance implementation, and chose to concentrate on teacher training. Discussions with regular school teaching staff from the schools involved in our initial efficacy trial confirmed that our interest in implementation was justified. Staff expressed doubts about their abilities to deliver the curriculum effectively without training. Their comments echoed the experience of Best and colleagues, who have identified "provider or teacher training" as one of several important factors which could influence widespread diffusion of health promotion and disease prevention curriculum.[6]

Therefore, we developed a computer-based teacher training model designed to equip regular classroom teachers with the knowledge and skills necessary to implement the heart health curriculum with high fidelity. We chose a computer-based model because we believed that computer-assisted instruction (CAI) could produce desired outcomes with respect to specific teacher variables mediating program implementation. For instance, it has been demonstrated that CAI can effect significant changes in health-related knowledge and attitudes,[25-26] and has also been shown to influence health-related behaviors both in clinical[27-28] and non-clinical populations.[29-31] In addition, computers are thought to be capable of enhancing intrinsic motivation by placing students within an active learning environment and providing individualized feedback.[32] In this respect, CAI appears to have an advantage over more traditional educational methods (i.e., use of written materials or pamphlets) which are thought to encourage passive learning and lack intrinsic appeal.[32]

The Stanford Computer-Based Educator Training Intervention (SCETI) was designed to meet two objectives. First, we wished to provide teachers with extensive instruction in CVD risk factor concepts. To accomplish this objective, SCETI presented teachers with knowledge items extending beyond the material covered in the student curriculum so that teachers would feel more comfortable delivering the curriculum and answering sophisticated questions. In addition, we were interested in investigating the impact of SCETI in self-reported health behaviors. Second, we wished to assess the effects of SCETI on a number of teacher variables mediating program implementation, including comfort with and acceptance of the program, enthusiasm and preparedness.

Methods

Design

Teachers from six high schools in two San Francisco Bay Area school districts participated in the study. Teachers were randomly assigned to training condition by school: teachers from three schools received the SCETI program, while teachers from the other three schools attended a half-day training workshop. Both the training workshop and the SCETI program required approximately 4 - 5 hours to complete, both covered the same curriculum content, and both were designed and delivered by the first author.

Subjects

Sixteen physical education teachers participated in the study. Six of the teachers were female, and ten were male. Of these sixteen, seven teachers were assigned to the SCETI condition, and the remaining nine teachers participated in the half-day training workshop. None of the seven SCETI teachers had appreciable prior experience with computers: four reported only minimal previous experience with computers, and three had no previous experience with computers.

Development and Delivery of the SCETI Program

Principles of Programmed Instruction

The underlying principles guiding the development of the SCETI program were derived from research examining the use of programmed instruction (PI) in the development and delivery of instructional materials.[33] This research has yielded several operative principles to guide developers of instructional materials. In brief, important features of effective PI include: (a) presentation of instructional material in a pre-planned, pre-sequenced order, (b) frequent, active responding by the learner, and (c) prompt feedback of the correct response. Experimental evidence demonstrates that instructional methods that foster active, explicitly occasioned responses are superior to methods which do not.[33] As this work indicates, practice of correct responses, whether overt or covert, is especially effective when followed by the provision of the correct response.[34]

Based on these principles, we developed SCETI: an interactive computer program written in HyperTalk scripting language for use on the Apple Macintosh personal computer. SCETI requires 1 MB RAM, 1.8 MB of disk space, HyperCard 2.0, and Macintosh System 6.0.5 or greater. The program is comprised of multiple "cards", each of which contains specific text, graphics, and navigational tools (see Figures 1-5). Upon beginning the program the learner is presented with an Overview Card outlining the available options: (1) Program Units, including "The Development of Coronary Heart Disease", "Exercise", "Nutrition", "Smoking Prevention/Cessation", and "Stress and Coping", (2) Program Help, including a list of symbols used in the program and a checklist to guide program completion, (3) Program Information, including SCETI objectives and user support, (4) Program Glossary, including a list of CVD terms (e.g., "cardiovascular", "cilia", "occlusion", etc.), and (5) Program Pretest and Posttest to assess changes in knowledge. The

learner simply clicks on the various icons representing these options to navigate through the program.

Program Units: Applying the Principles of Programmed Instruction

Each program unit consists of four major components: a topic card, information cards, review cards, and help cards. Within any program unit, the learner is provided with the opportunity to browse through an array of information on any number of specific topics: the topic card identifies the various topics available. For example, the "Development of Coronary Heart Disease" unit contains four topic: "Atherosclerosis", "Cholesterol", "Heart Attack" and "Cardiac Arrest" (see Figure 1). Topic areas containing complicated or dense information are broken down into subtopics. For example, the "Cholesterol" topic contains the following subtopics: "Cholesterol Facts", "LDL Receptor Hypothesis", and "Endothelial Injury Hypothesis." Once the learner selects a topic or subtopic, they are provided with a series of sequenced information cards on that topic or subtopic area. The material contained in these cards is presented via text and graphical representations (see Figure 2). For example, a learner who has selected the "LDL Receptor Hypothesis" subtopic under the "Cholesterol" topic, will see a graphical representation of LDL in the blood stream to serve two functions: (1) presentation of basic vocabulary, and (2) introduction to facts about LDL binding. As the learner progresses through the unit, the image changes to reflect progression of the binding process (see Figure 3). Throughout the program, teachers are provided with the option of actively investigating subject areas in more detail if they so choose. Information cards are used in this manner to apply the first principle of programmed instruction: to provide the learner with information in a pre-planned, pre-sequenced manner.

After the learner finishes reading all of the information cards within a given topic or subtopic, they are provided with a series of review cards. Each review card contains a question and a number of possible answers (see Figure 4). The learner is asked to select the correct answer to demonstrate an understanding of the topic content. In this way the second principle of programmed instruction is applied: frequent, active responses are required of the learner.

Following each response, the learner is provided with immediate visual and auditory feedback. In the case of a correct response, the learner receives acknowledgment and is allowed to continue to the next question. In the case of an incorrect response, the learner is offered a hint card (see Figure 5). The learner may try selecting a different answer, or may read the hint card. Only after the learner has correctly answered the question may he or she continue to the next question. In cases of incorrect responses, a follow-up review question on the same material is presented to provide the learner with a second opportunity to demonstrate understanding of the content. These follow-up cards are also linked to hint cards in the case of a second incorrect response. Upon successful completion of the follow-up review question, the learner continues with the remainder of the review cards until completed. Thus, the review and hint cards apply the third principle of programmed instruction: prompt feedback of the correct response.

Program Structure: Taking Advantage of CAI Features

SCETI was designed to incorporate several features afforded by CAI in an effort to maximize the effectiveness of the PI-based approach:

1. Information is presented across multiple modalities.

Written text, audio, and graphical representations were used concurrently on all cards presenting information to the learner. Text and non-text information supplemented each other in this approach: for example, images of a developing atherosclerotic lesion were displayed next to a written description of the event. In this way the material was presented in numerous ways across multiple modalities.

2. Motivation for program completion is provided.

It was assumed that the PI-based program would be successful only if the learners completed the entire program. Accordingly, SCETI was designed to enhance intrinsic motivation by placing learners within an active learning environment, probing for responses to questions, and providing individualized and immediate feedback.[32] In comparison to more traditional educational methods

(i.e., written materials or lectures), which are thought to encourage passive learning and lack intrinsic appeal, CAI fosters interesting, active and exploratory learning and may result in more beneficial educational outcomes.[35]

3. Immediate access to cross-references is provided.

Prompt feedback of correct responses often leads to learner questions. In order to provide learners with additional information on specific topics, cross-references were provided throughout the program. In contrast to written manuals, CAI-based cross-references may be accessed instantly. For example, a student completing a manual-based unit on nutrition would use the index to find the location of other references to "saturated fat," and would then look up each individual reference separately. However, a student completing a CAI-based nutrition unit could be linked immediately to multiple other "saturated fat" references, in a logical order, by providing a single command.

Content

A content analysis of the Stanford Adolescent Heart Health curriculum[36] was performed to determine the instructional material to be included in the SCETI program. However, because we decided that it was important to provide teachers with a knowledge base that extended beyond the material covered in the curriculum, we compiled a list of more advanced knowledge items, not included in the Adolescent Heart Health curriculum, for inclusion in SCETI and in the training workshop.

Method of SCETI Delivery

Each teacher in the SCETI condition received an Apple Macintosh SE microcomputer and the SCETI program for a period of one month. Teachers were free to complete the SCETI program at school or take the computers home with them. Because none of the teachers in the study had extensive previous experience with computers, we developed an "Introduction to the Macintosh" training session which was delivered directly to teachers at the same time they received their computers. This "Introduction to the Macintosh" training focused on how to use a Macintosh, how to begin SCETI, and how to work through SCETI. This training took approximately 45 minutes.

At the end of the month, the machines were retrieved and data were extracted from the unobtrusive monitoring system built into the SCETI program. A short questionnaire on program usage was also administered to SCETI condition teachers at the end of the intervention.

Development and Delivery of the Half-Day Training Workshop

All teachers assigned to the workshop training condition attended a half-day training session. The training session was designed to provide teachers with a comprehensive review of program concepts, as well as curriculum materials. The training session consisted of lecture, curriculum guide review, and discussion. All workshop condition teachers completed this training.

Evaluation

Unobtrusive Monitoring of Program Use

An unobtrusive monitoring system was written into the CAI software so that teacher progression through the program could be recorded without the teacher's awareness. This monitoring system was written so that the research team would be able to determine: (a) whether or not the teacher completed the program, (b) in what order the teacher completed the program, and (c) shifts in knowledge from pretest to posttest.

Knowledge Assessments

CAI condition teachers were instructed to complete a computerized 19 item knowledge pretest before beginning the program. Teachers were provided with the total number of items answered

correctly in order to provide feedback on their overall understanding of the material prior to program exposure. To avoid bias, we did not provide teachers with answers to individual items. However, the unobtrusive monitoring system placed each of these answers into a hidden field so that knowledge gains could be assessed.

After finishing the program, teachers were instructed to complete the same 19 item assessment. As before, each teacher was provided with the total number of items she or he answered correctly, while the specific answers were placed into a hidden field. In addition, the date and time at which the teacher took the pretest and posttest was also recorded in order to provide the study team with an indication of compliance to program protocols.

Teachers in the workshop condition were administered a pencil and paper knowledge assessment after exposure to the four hour training workshop. Pretest knowledge was not assessed. The 19 item assessment contained the same items delivered to SCETI condition teachers.

Behavior Change Items

Upon completion of the CAI software, teachers were asked to complete a short questionnaire assessing changes in their attitudes and behaviors. To evaluate behavior change, the following question was posed for each program unit (i.e., Introduction to Coronary Heart Disease, Exercise, Nutrition, Smoking Prevention/Cessation, and Stress and Coping): "How influential was the unit with regard to the modification of your own health-related behaviors?" Additionally, teachers were asked: "Overall, how much did SCETI influence you to change your own health-related behaviors?" Responses were made on four-point Likert-type scales.

Implementation Items

Implementation variables were also assessed via the self-report questionnaire. To assess comfort with and acceptance of the program, these questions were posed: "How difficult was it to learn how to use the Macintosh computer?", "How difficult was it to learn how to use the SCETI program?" Additionally, for each program unit , these questions were asked: "How difficult was the material to understand in the unit?", and "How interesting was the material in the unit?" To evaluate enthusiasm we asked teachers: "How much did you like using the SCETI program?". To assess preparedness we asked the following question for each program unit: "How well do you feel that SCETI prepared you to teach the unit?" All responses were made on a four-point Likert-type scale.

Statistical Analysis

Knowledge gain was assessed from pretest to posttest among CAI taught teachers using a t-test. One-way analysis of variance (ANOVA) was used to compare posttest knowledge scores for both CAI and Workshop taught teachers.

Results

Program Use

Data from the unobtrusive monitoring system revealed that of the seven teachers who received SCETI , six fully completed the program (86%). The remaining teacher completed the computer-based pretest and posttest (in reverse order), but did not complete any other program components. This teacher's data were subsequently excluded from further analyses. Of the six teachers who did use the training software, all six fully completed the program.

Knowledge Gains

Knowledge shifts from pretest to posttest indicate that SCETI condition teachers (n = 6) demonstrated a mean increase of 6 correct items ($p < .0001$), with one teacher improving his score from 7 of 19 correct at baseline to 16 of 19 correct at posttest. Baseline scores for all SCETI teachers averaged 8 of 19 correct (SD = 1), while posttest scores averaged 14 of 19 correct (SD = 2).

Comparison of posttest knowledge scores for teachers from the SCETI and workshop training conditions indicates that workshop trained teachers averaged only 10 of 19 correct items following training (SD = 1) vs. the SCETI teacher average of 14 correct of 19 (SD = 1) [$F(1, 13) = 12.06$ $p<.004$].

Self-Reported Changes in Health Behaviors

Four of the five SCETI units (i.e., Introduction to Coronary Heart Disease, Exercise, Nutrition, and Stress and Coping) appear to have been influential in the modification of teacher health behaviors. Five of the six SCETI condition teachers reported that each of these units was either "very influential" or "somewhat influential" in the modification of their own health behaviors. All teachers were non-smokers, so questions regarding the modification of smoking behaviors were not applicable. Similarly, when asked to rate SCETI's overall influence in the modification of personal health behaviors, five of the six teachers reported that SCETI had influenced them either "a great deal" or "somewhat."

Implementation Variables

Comfort With and Acceptance of the Program

Self-report data from these six teachers suggest that the teachers found both the computer and the SCETI program easy to use. Four of six teachers reported that learning to use the Macintosh was "very easy", while two of the teachers found learning to use the Macintosh "somewhat easy." Five of the six teachers thought that learning to use SCETI was "very easy", and one person found learning to use SCETI "somewhat easy."

Teachers also reported on the level of difficulty associated with the material in each program unit. With the exception of the Smoking Prevention/Cessation unit, four of the six teachers rated the units as "not very difficult" or "not at all difficult", with the remaining teachers rating the units as "somewhat difficult." No teacher rated any of the units as "very difficult." Five of the teachers rated the Smoking Prevention/Cessation unit as either "not very difficult" or "not at all difficult", with the remaining teacher rating the unit as "somewhat difficult."

Teachers also rated how interesting they found the material in each of the program units. All six teachers reported that the Introduction to Coronary Heart Disease unit was "very interesting." Similarly, the Exercise, Smoking Prevention/Cessation and Stress and Coping units were rated as either "very interesting" or "somewhat interesting" by all six teachers. The Nutrition unit was rated "very interesting" by four teachers, "somewhat interesting" by one teacher, and "not very interesting" by one teacher.

Enthusiasm

Teachers reported that they enjoyed using SCETI. Four of the six teachers liked SCETI "a great deal" and two of the teachers liked SCETI "somewhat."

Preparedness

All six teachers reported that four of the five program units (i.e., Introduction to Coronary Heart Disease, Exercise, Smoking Prevention/Cessation, and Stress and Coping) prepared them to teach the program material either "very well" or "somewhat well." Five of the six teachers reported that the Nutrition unit prepared them either "very well" or "somewhat well", with the remaining teacher responding that the unit "did not prepare me very well."

Discussion

Even with the small sample, findings from this study suggest that exposure to the PI-based SCETI program resulted in significant knowledge gains from pretest to posttest. Results also indicate that CAI condition teachers learned significantly more than did those in the comparison group. Although limited to an after-only analysis, we were able to eliminate a number of potential confounds often observed in other CAI studies[37] by controlling for length of exposure to intervention, the amount and content of the material presented, and the level of expertise utilized in the development and delivery of both interventions. Additionally, the data suggest that four of the five CAI units were influential in the modification of self-reported teacher health behaviors, arguably the most important outcome of any health behavior education intervention. While the absence of self-report data for workshop condition teachers precludes the evaluation of behavior change differences between groups, available data do support the claim that PI-based CAI may be influential in the modification of certain behaviors. Given that teacher behaviors are closely scrutinized by students, this could be an especially important outcome. By "practicing what they preach", teachers may be potentially powerful agents of behavior change in their students. Given these findings, it appears that theory-driven CAI is not only capable of producing statistically significant increments in knowledge gain, but may also result in pedagogically important gains as well.

In addition to knowledge gains and self-reported shifts in health behaviors, theory-based SCETI appears to have affected several teacher variables mediating program implementation, including comfort with and acceptance of the program, enthusiasm and preparedness. As mentioned, teachers initially expressed concerns about their abilities to deliver the curriculum effectively. Some teachers also later indicated that they were afraid to use computers, and were uncomfortable with the idea of computer-based training. These concerns were not unanticipated. In our experience, some teachers will be uncomfortable in implementing new curricula when the subject matter, training methods, or teaching skills are unfamiliar, as is frequently the case with health promotion and disease prevention curricula. However, in spite of their initial concerns, SCETI teachers' self-report data suggest that the methodology employed in the development and delivery of the SCETI program alleviated many teacher concerns, increased teacher comfort with and enthusiasm for the program, and enhanced teacher preparedness to deliver the program.

From a cognitive social learning perspective,[38] an effective training program provides teachers with mastery experiences which boost perceived efficacy for implementing a curriculum with success. Mastery experiences are expected to have a positive impact on other variables important to program implementation such as teacher self-efficacy and perceived preparedness to deliver the curriculum. We believe that PI-based SCETI had a positive impact on teacher variables important to implementation because it provided a powerful mastery experience for teachers. Teachers were allowed to proceed through the program only after successful completion of each knowledge section. In this manner, teachers were provided with continuing mastery experiences throughout their training, thereby leading to increased self-efficacy for effective program delivery.

These results suggest that the use of PI-based CAI in teacher training may not only lead to increased knowledge of the curriculum content, but may also positively impact a number of teacher variables mediating program implementation, potentially resulting in more effective diffusion of school health education and other curricula. In addition, PI-based CAI, compared to more traditional training programs, also offers the following advantages:

1. Standardized Instruction

Compared to the workshop training format, in which workshops would necessarily be conducted by persons with different levels of skill and training, computer-based training offers a far more standardized instructional environment.

2. Flexibility

Optimal learning occurs at different speeds for different persons. Although the content is standardized, CAI allows self-pacing to maximize learning potential.

3. Ease of Updating Curricula to Reflect Scientific Advances

Health education programs require updating as research produces changes in our understanding of disease processes. Compared to the retraining of workshop leaders or master teachers, the CAI software can be updated to reflect new information far more quickly and less expensively.

4. Availability

For convenient adoption of school curriculum, teacher training resources must be intermittently available. This would require either constant training of new trainers or a full time training staff to meet intermittent demands for training. CAI is a potentially powerful and cost effective alternative.

Despite the potential advantages associated with PI-based CAI, we are not so naive as to suggest that CAI is a panacea for all the problems encountered in efforts to diffuse school health curriculum. However, we do feel that training via computer represents an attractive and relatively inexpensive alternative to other teacher training models and a supplement to others. Only through further research in program diffusion will we learn whether health behavior change programs can be implemented via PI-based CAI in a large-scale, cost-effective manner.

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Figure 1

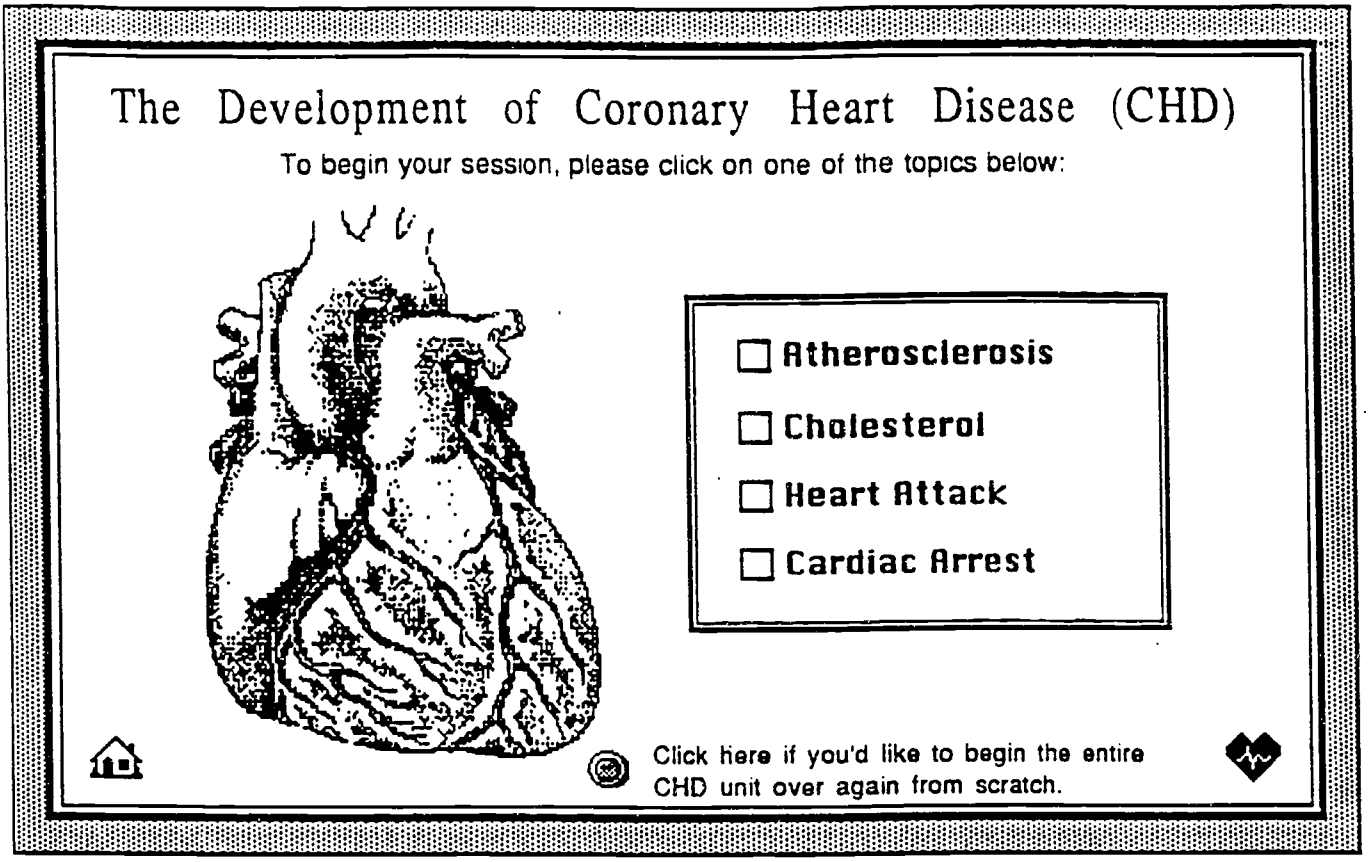


Figure 2

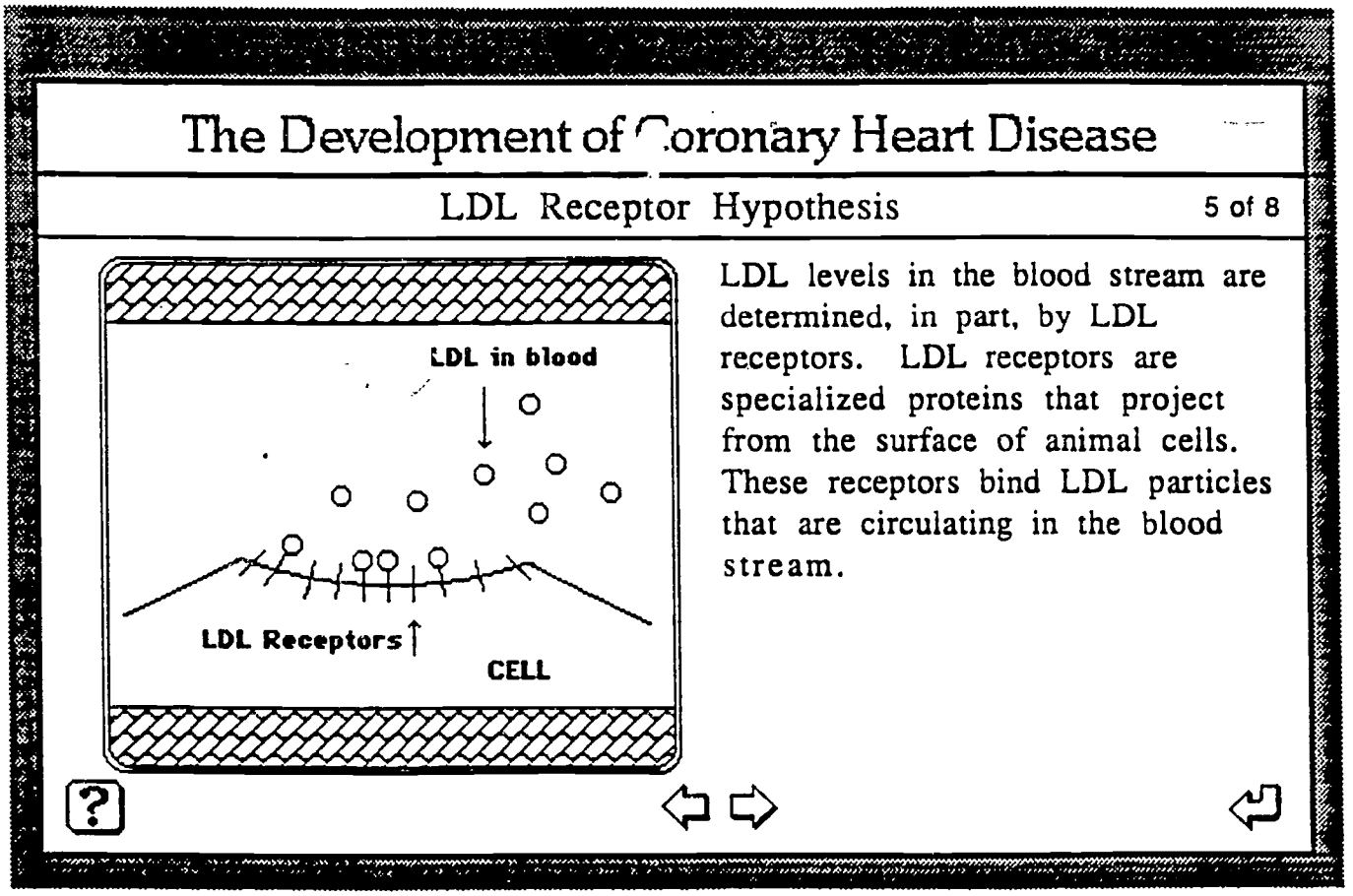


Figure 3

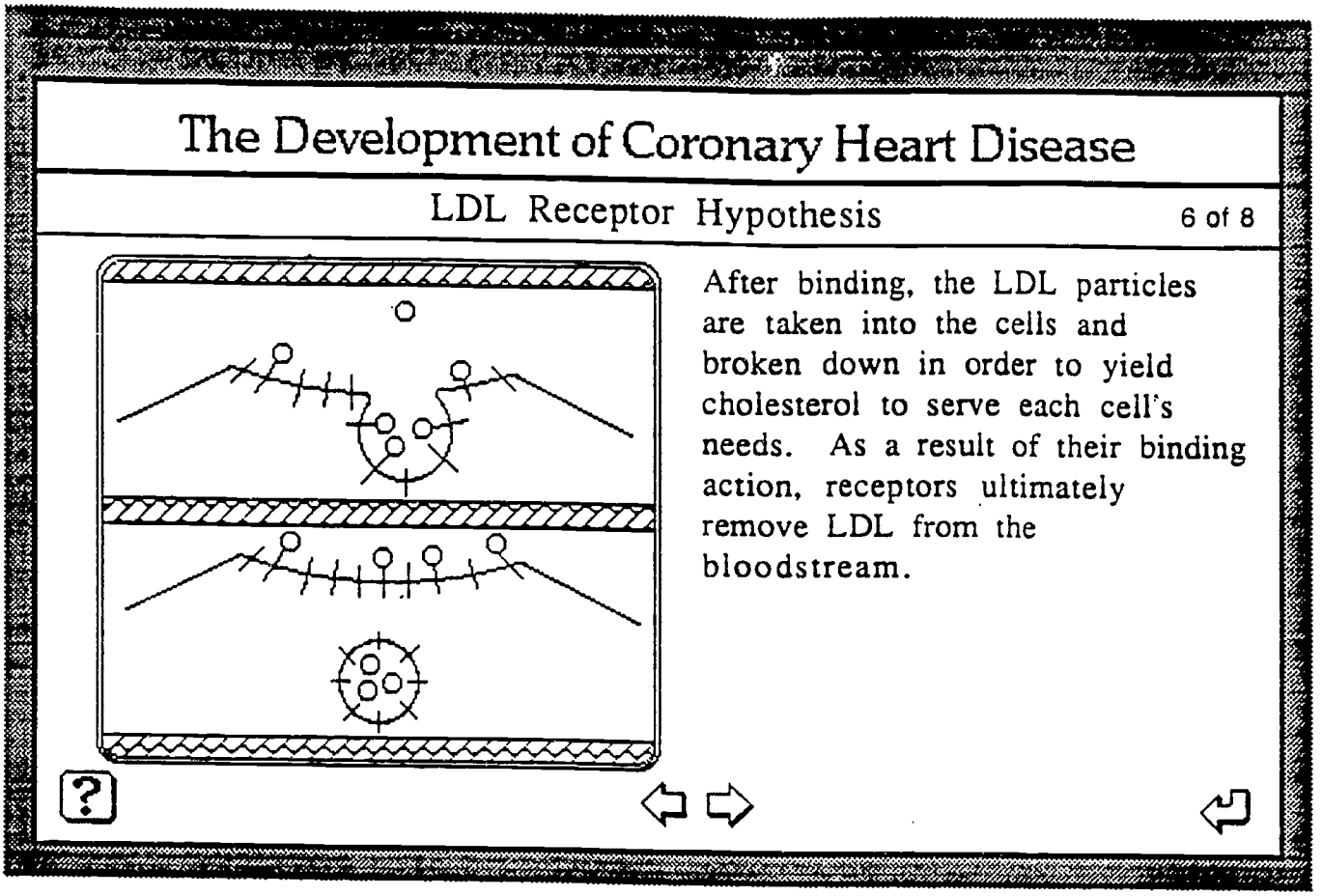


Figure 4

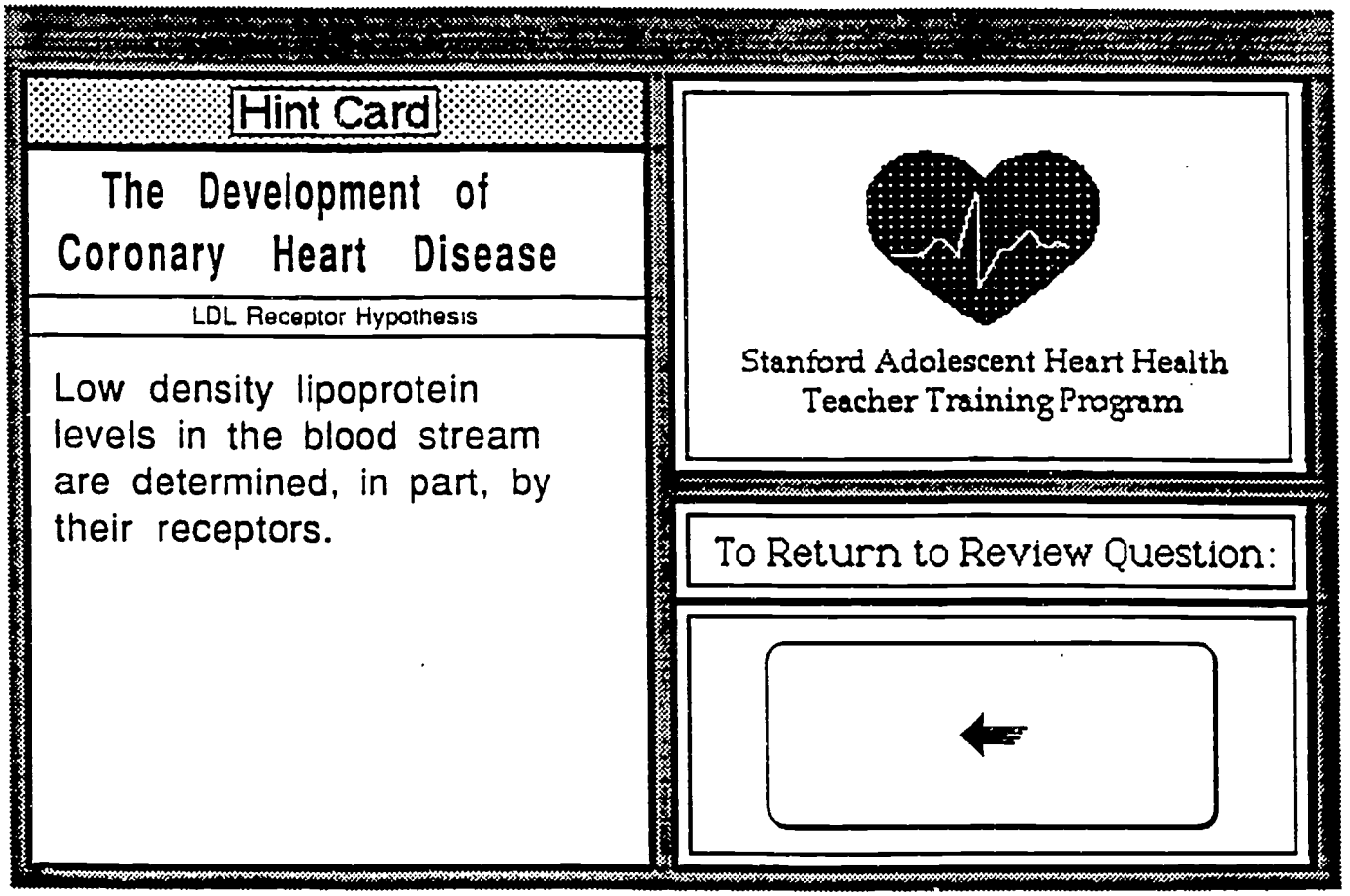
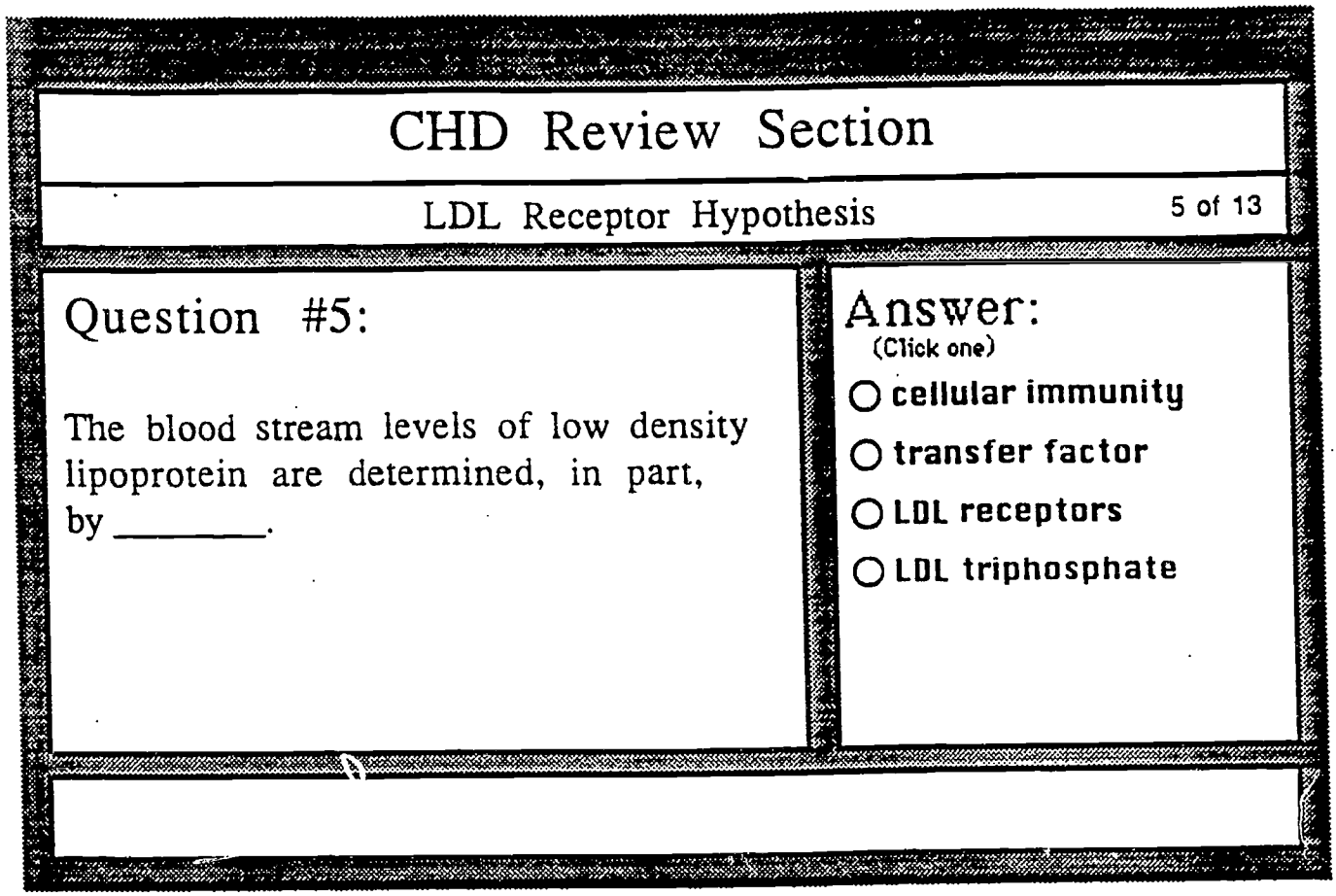


Figure 5


CHD Review Section
LDL Receptor Hypothesis
5 of 13
Question #5:
The blood stream levels of low density lipoprotein are determined, in part, by _____.
Answer:
(Click one)
cellular immunity
transfer factor
LDL receptors
LDL triphosphate