DEVELOPMENT OF COMPUTERIZED VIRTUAL AND TEXT-BASED SIMULATION TESTING ENVIRONMENTS

by

Carol Lorraine Brinkman

A THESIS

Presented to the Division of Medical Informatics and Outcomes Research

and the Oregon Health Sciences University

School of Medicine

in partial fulfillment of

the requirements for the degree of

Masters of Science

May 2000

[redacted]

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

A special measure of thanks is due to Dr. Dana Braner of the Department of Pediatrics at Oregon Health Sciences University for his extensive support in the completion of this thesis. A special measure of thanks is also due to Dr. Joseph Zenel of Department of Pediatrics at Oregon Health Sciences University for his much needed assistance and provision of examination material. Recognition is also given to Dr. Paul Sher of the Division of Medical Informatics and Outcomes Research at Oregon Health Sciences University for his insight, help, and general support, and to Dr. William Hersh of the Division of Medical Informatics and Outcomes Research at Oregon Health Sciences University for making possible the completion of this thesis.

ABSTRACT

While much debate has occurred over the use of simulation testing in medical education, no research has been done to provide insight into the benefits of simulation testing. The goal of this thesis was to develop a pair of programs to allow comparison of the different formats of a text-based and virtual patient simulation test as a first step toward researching this issue. The development of these programs was based on computer system development standards and utilized multimedia elements for the virtual patient simulator test from a multimedia pediatrics database. The contents of the programs focused on pediatric medicine with the examination material provided by pediatric teaching facility from Oregon Health Sciences University. Pilot testing of these programs was performed on third-year medical students completing a six-week pediatrics rotation. The results of the thesis reveal this pair of programs to be an effective tool to conduct this type of research. With additional enhancements, these programs could be even more effective and helpful in resolving the question of whether there are differences or benefits of simulation testing in medical education.

INTRODUCTION

Much debate and experimentation has taken place during the past several years concerning the most effective means of assessing medical knowledge, competency, and performance. The central issue behind this debate has been how to best simulate the actual clinical environment in which most clinicians will practice in order to be able to evaluate the skills they will require for that practice. Although simulation has been described (Bersky and Yocum, 1994; Clauser et al, 1993; Forker and McDonald, 1996; Keels and Dear, 1996; Weiner et al, 1993; Wesley et al, 1995; Wofford and Wofford, 1995), to date, there has not been an attempt made to determine whether this is a better method of testing than traditional means. Traditionally, paper-based multiple-choice examinations, which are not interactive and do not simulate the clinical encounter, have been used in the process of knowledge assessment. However, these are considered by many to be unreliable in accurately determining a person's level of medical knowledge, competency, and performance because of cueing effects (Clayden, 1996; Okasha, 1997). A cueing effect is the tendency for a test to direct or lead examinees to the correct answer because the case description provides information that results in the elimination of much of the interpretive and problem-solving skills required in real-life situations. The concern over cueing effects has led to the support of a number of different testing formats designed to reduce or eliminate them, with multimedia simulation testing receiving the majority of the support. Despite the fact that no research has been conducted to validate the belief that simulator tests are more effective in assessing clinical skills than traditional multiple-choice tests, their usage has become more extensive throughout medical education. Cavanaugh, in his work on, "Computer Simulation Technology for Clinical Teaching and Testing" (Cavanaugh, 1997), emphasizes the need for such research:

> "While the technology is promising, much research regarding the role of simulator training in medical education is needed...Ultimately, salient questions for research include: 1) Are skills learned from simulation exercises or devices transferable to real patients? 2) Does performance mastery in the simulation setting translate to performance mastery in the clinical setting?"

For purposes of clarification, the following definitions of knowledge, competency, performance, and clinical competency are provided. Definitions of a simulator and multimedia are also provided.

- Knowledge: what is learned from data and information and what can be applied in new situations to understand the world.
- Competency: the ability to perform particular activities to prescribed standards.
- Performance: psychomotor, cognitive, and affective skills.

- Clinical competency: specifically, relates to a physician's ability to perform three functions:
    - 1) Access a knowledge base (medical facts),
    - 2) Apply medical facts through clinical reasoning to solve or diagnose medical problems, and
    - 3) Perform critical procedures and treatments.
- Simulator: an examination or device that enables the operator to reproduce under test conditions phenomena likely to occur in an actual clinical environment.
- Multimedia: pictorial, audio, or video elements used as a medium to capture or replicate real clinical experiences.

Multimedia elements may be thought of as replicating clinical experiences. Programs that do not use multimedia, but that are interactive, may be thought of as replicating, to some degree, clinical encounters. While a program containing multimedia elements may be considered a simulator, a more robust example of a simulator would be a program that combines multimedia elements in an interactive setting. A program that incorporates the replication of clinical experiences and clinical encounters by changing the presentation of the material while in the program is in progress may be thought of as the most advanced type of a simulator example.

The purpose of this project was to develop two computerized examinations; one that utilizes multimedia elements to simulate clinical experiences and is designed for extensive user interaction, and the other one based on textual information with limited user interaction. Both were designed to have certain qualitative and quantitative characteristics that are desirable in a computer system. Refer to figures 1 and 2 for sample screens of these programs.

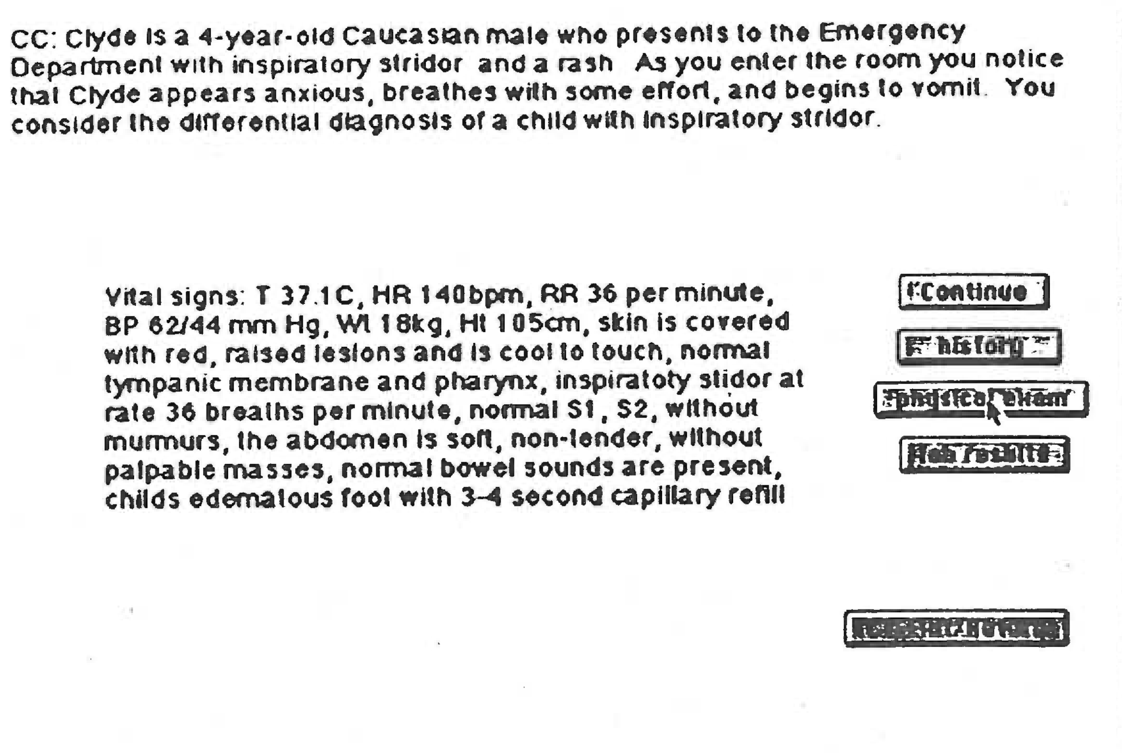

Figure 1. Sample Screen of Text-based Program

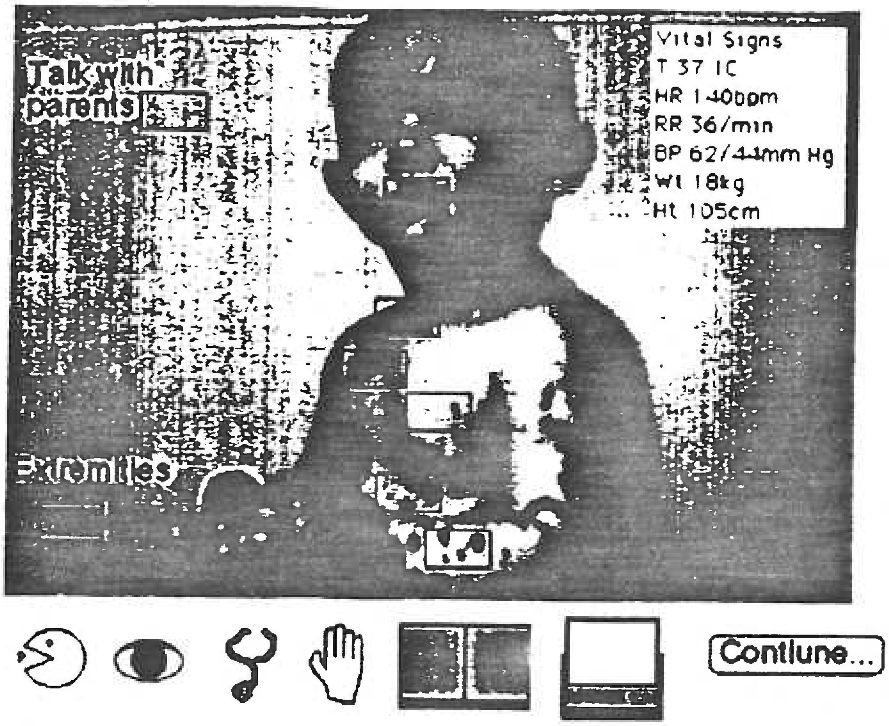

Figure 2. Sample Screen of Virtual Patient Program

This paper will discuss previous work that has been done in this field and the design methodology which was applied in the development phase. It will then proceed to describe the details of the application of those design principles to the project requirements. Lastly, it will report on a pilot study using the examinations and their evaluation tools.

BACKGROUND

The Use of Simulation and Multimedia in the Testing of Medical Knowledge, Competency, and Performance

One of the first simulations - simulated clinical experiences - in medical testing was introduced in 1965 by the National Board of Medical Examiners. In Part III of their examination, a standardized test taken by many physicians during training, multimedia elements were used. Specifically, motion picture clips were used in a section which by design required interpretation of clinical data presented in pictorial or graphic format. In a review of the proposal on this examination, Hubbard (Hubbard, 1965) explains that it was theorized that motion picture presentation would allow for objective evaluation of both observation acuity and of the conclusions derived from those observations. It is also theorized that the design of the test questions - specifically, allowing the examinees to indicate which diagnostic tests they would want in this clinical encounter - would provide a method of objectively evaluating the examinee's ability to interpret a variety of clinical data.

In a more complex but non-multimedia simulation, the American College of Physicians (ACP) computerized an examination which they use for accrediting continuing education hours for physicians. The Computerized Patient Management Problems (CPMP) give some preliminary information about the patient, then give the examinee several options. The examinee may take a history, perform a physical examination, or order laboratory or imaging studies. The test then requires the examinee to conduct some form of therapy. The status of the patient's condition changes in accordance with the examinee's choice of treatment. It is believed that this testing format allows examinees the same or similar options as those found in a typical clinical encounter (Takabayashi, 1995).

Mihalas and associates (Mihalas, 1995) looked at existing simulation experiences in medical education, whether used for training or for testing. They categorized the simulators by their level of sophistication or usefulness.

The markers that they looked for in these programs included, first, the ability of the program to generate at runtime either changes to specified cases or choice of case presentations and, second, the ability to use the program to evaluate knowledge. From least to most sophisticated, they describe the various programs as follows:

- Shows normal or pathological values, runs default cases and allows changes of the initial situation prior to runtime but does not handle either the generation of other cases within the program or the evaluation of the student's knowledge. This type of simulation program would be used for training purposes only since it does not evaluate the student's knowledge. It is "static" in that different case scenarios cannot be produced after the program has been initiated.

- Generates several situations, but has limited performance on evaluation. This type of simulation program would also be used primarily for training purposes since it does not extensively evaluate the student's knowledge. It is "dynamic" in that different case scenarios can be produced after the program has been initiated.
- Generates several cases and also gives students evaluation. This type of simulation program would be used for testing purposes since it evaluates the students' knowledge. It is also "dynamic" in that different case scenarios can be produced after the program has been initiated.
- Traces the students' thinking during examination. This type of simulation could be used for testing purposes since it evaluates the students' knowledge. It traces the students' thinking by recording the actions or responses that the students perform.

<u>Prior Research on Effective Means of Testing Knowledge, Competency, and Performance:</u>

There have been a number of attempts, in the design of various simulation programs, to enable effective measurement of clinical knowledge, competency, and performance. However, validation of the effectiveness of any of these programs, in this author's opinion, has not occurred. If one was to judge a simulator's level of effectiveness by its level of sophistication as described by Mihalas (Mihalis, 1995), the characteristic of a simulator that would be the best indicator of its effectiveness would be its ability to trace a student's thinking during examination. To date, none of the existing medical-related simulators described in the literature have the capability of tracing a student's thought process. Perhaps the simulator test that comes closest to having this capability is the ACP's CPMP previously described (Takabayashi, 1995). However, since this simulator attempts to reproduce the clinical encounter but not the clinical experience, that is, it is interactive but text-based, concerns over cueing effects still exist.

Design Methodology:

In order to devise a strategy for systematically developing the two examinations in this project, the process of computer systems development was researched. The development process that was selected for this project was based on the desire to develop a research tool rather than a commercial product. The desired end result of this main process was examinations with certain quantitative and qualitative characteristics; to help achieve the qualitative characteristics, certain layout design principles were utilized in the development of the computer screen displays.

Despite the fact that there is no design methodology considered to be the "golden standard" in the field of computer systems design, there is a general consensus on three main steps involved in systems development. These three main steps are described by Cox and Walker (Cox and Walker, 1993) as the following:

- *Exploration of the problem to be solved.* This is a mental exercise aimed at "coming to grips" with the problem. The techniques used have two main purposes: to organize and relate different aspects of the problem, and to look at the problem in as many different ways as possible.
- *Generation of ideas.* This is the creative part of design where the potential solution is generated. It may be thought of as a leap of the where a lot of disparate ideas come together into a coherent whole.
- *Evaluation of the solutions.* This is done to see whether or not the solutions chosen will work and to select one or more of the "best" solutions for further work. This stage of the process is a major source not only of problems to be fixed but also of new ideas for the beginning of the next cycle of design.

These steps of the design process are repeated with each cyclical iteration resulting in a refinement of the system being designed. Once designed, there are criteria for quantitatively evaluating the system, which are as summarized by Yourdon and Constantine (Yourdon and Constantine, 1979) as follows:

- *Reliability.* This characteristic tells us that the program will work, as expected, when we want it to, and will give dependable results.
- *Maintainability.* This means that if something goes wrong, we can correct it.

- *Modifiability.* This characteristic refers to our ability to adapt the program for changing circumstances.
- *Efficiency.* This characteristic means that the program does not take an excessive amount of resources to operate.
- *Usability.* This is a characteristic that is reflective of the other characteristics: the concept that building a reliable, maintainable, easily changed, efficient product is worth doing as our users can and will use the product.

The objective of using the three steps of exploration, idea generation, and evaluation of solutions in the main development process was to develop a system with the desired qualitative features of user control, transparency, flexibility, and learnability. Cox and Walker (Cox and Walker, 1993) define these qualities using the analogy that a good computer system is akin to a good tool, as follows:

- *User control.* The user is in charge at all times and dictates what the tool is to do, and not vice versa.
- *Transparency.* The tool becomes an adjunct to the person, so that the user can apply their thoughts to the problem at hand, and not the manipulation of the tool.
- *Flexibility.* The tool can be used in a variety of different ways and for a range of purposes, many of which were unintended by the original designer.

- *Learnability.* It must be relatively easy to perform basic activities with the tool, and it must be such that users can increase their skills through use.

In order to help achieve these qualities, certain layout design principles can be used in the development of the screen displays. These design principles summarized by Cox and Walker (Cox and Walker, 1993) are:

- *Balance.* This requires the of harmonious use and ratios of different elements.
- *Regularity.* This requires the use of elements in a consistent manner and symmetry of the elements used – such as to produce axial duplication – in order to manufacture predictability of the program.
- *Economy.* This characteristic reflects the judicious use of elements such that they are neither excessive nor lacking.
- *Sequential.* This quality refers to the logical flow or progression of elements.
- *Proportion* . This characteristic refers to the shape, ratio and juxtaposition of elements, e.g. the "golden rectangle" with the ratio 1 height : 1.618 wide.

DESCRIPTION OF PROJECT DEVELOPMENT

The purpose of this development project was to construct two different computerized examinations focused on the initial evaluation and management of pediatric patients. These examinations are designed to contain the same clinical content, and the same type, number and sequence of questions, but differ in the manner in which the clinical content is presented to the subject. The two ways in which the presentation of the clinical content are different is in the use (or lack thereof) of multimedia elements (i.e. video, graphics, and audio clips) and in the degree of interaction the subject must have with the program in order to solicit the clinical information.

For the purposes of clarification and consistency, the two examinations will be referred to as the "text-based test" and the "virtual patient simulator" in this project description. The examination containing information presented only in textual format will be referred to as the "text-based test". The examination containing information presented with the use of multimedia elements will be referred to as the "virtual patient simulator".

Resources

The resources used for this project were Macintosh computers, elements from a multimedia database, multimedia project development software, and pediatric teaching faculty at Oregon Health Sciences University (OHSU). In addition, a number of digital cameras, and microphones, and video and audio-editing software were also needed for the collection of the multimedia material which is maintained in the OHSU pediatric multimedia database.

Computer Equipment

The specific computer equipment that was used was a Macintosh PowerBook 5300cs Computer, a Macintosh 6500/250, and a Macintosh 9600/300 Computer with 140 megabytes of RAM and a four gigabyte AV rated hard drive. Connected to the Macintosh 9600/300 computer was an 18 gigabyte RAID disc array and a Media 100 board. To capture the pictorial and video material three digital cameras, a direct-to-digital video camera, and an UMAX powerlook 2000 scanner were utilized.

Multimedia Database

The multimedia database that was utilized was the pediatrics multimedia database at OHSU, to which the author contributed and assisted in compiling. This database contains over 1000 digitized pictures of pediatric diseases, radiological examinations, therapeutic procedures, and real-time videos of various diseases and treatments. It also contains several audio elements, such as lung and heart sounds. Multimedia elements from this same database have been used in the creation of the CD-ROM pediatrics textbook, Pediatrics: An Interactive Program , by Braner et al, published by Saunders.

Project Development Software

The project development software that was used for the compilation of this project includes Adobe Photoshop, Adobe After Effects, Media 100, SoundEdit16, Macromedia Authorware, and Macromedia Director. Adobe Photoshop and Adobe After Effects were primarily used in the editing process of all pictorial material. Media 100 was used to edit the video material and SoundEdit16 was used to edit all of the audio material. Macromedia Authorware version 4.0 was used in the development of the text-based test and Macromedia Director version 6.0 was used in the development of the virtual patient simulator. The choice of these authoring applications was made based on the type of media that was to be contained in each examination (i.e. text vs. multimedia) and the ease with which the authoring applications make the visual organizational of programs in the authoring state (i.e. help organize complex sections of 'code').

Pediatric Teaching Faculty

The 20 clinical cases used in these examinations were provided by Drs. Joseph Zenel and Dana Braner from the Department of Pediatrics at OHSU. Some of these cases had been used in Pediatrics: An Interactive Program. In addition, Dr. Joseph Zenel provided the material for the 100 questions used, including the correct and incorrect answers to each of the questions. Dr. Dana Braner assisted in modifying the case information from multimedia format for use in the text-based test. The clinical content of this project was specifically devised by OHSU pediatric teaching faculty, and not by the author, to validate its use in the examinations. Additionally, both Drs. Zenel and Braner contributed feed-back on the design of the programs and helped in the editing process.

Basic Design Issues in Production of the User Interface

The basic approach used in designing the programs was to follow a methodology of exploration, generation, and evaluation as described by Cox and Walker (Cox and Walker, 1993). The purpose of using this design process was to develop the simulators with the desired qualitative characteristics of user control, transparency, flexibility, and learnability. The quantitative characteristics that were desired were reliability, maintainability, modifiability, efficiency, and usability. (Yourdon and Constantine, 1979).

In order to successfully incorporate these desired qualities, it was necessary to address the design issues of flow control and choice of navigational aids in a comprehensive manner. Flow control is the purposeful limitation and direction of the subject in a manner appropriate for the program. Navigational aids facilitate the movement within the program from one screen to another or from a screen to information. Screen layout design issues were also aggressively addressed. Additionally, since the programs had to be designed from a research perspective, it was necessary to also keep in mind the concerns of potential biases and consistency between the programs. As a research tool, the programs were designed to capture several types of results.

It had been previously decided that a total of twenty patient cases would be used in each examination with each case having five multiple choice questions associated with it. The most logical construct of the examinations was to present each patient case scenario with its set of related questions following the case information. This resulted in each examination following a pattern of case scenario, then five related questions, then a new case scenario, another five related questions, and so forth.

Flow Control:

The goals in the design of flow control were first, to replicate the real-life clinical encounter as much as possible and second, to force progression through the examination. Ideas for replicating the clinical encounter included allowing subjects as much time as needed to make decisions and the option of reviewing the pertinent case information after viewing each question. However, as part of the goal of forced progression, the programs prohibit subjects from returning to previous questions or cases. In addition, the programs require that subjects view the questions in a set order, and to either answer or default on one question prior to viewing the next question. This flow is illustrated in Figures 3 and 4.

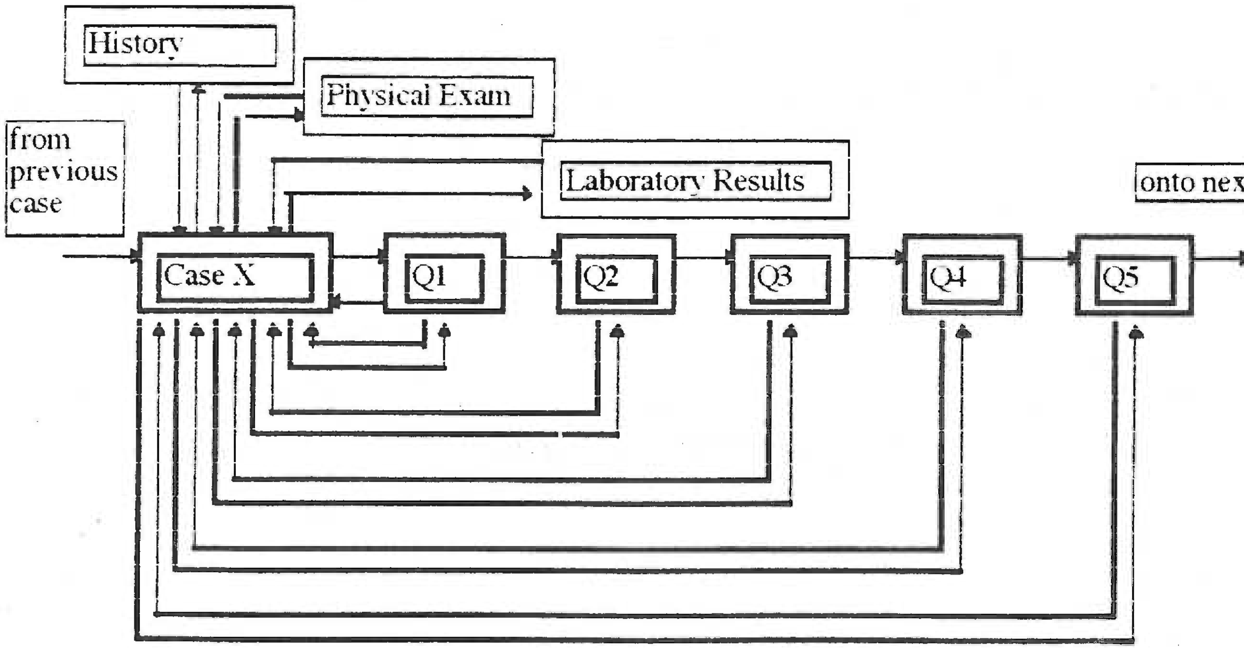

Figure 3. Schematic Diagram of Navigation of the Text-based Test

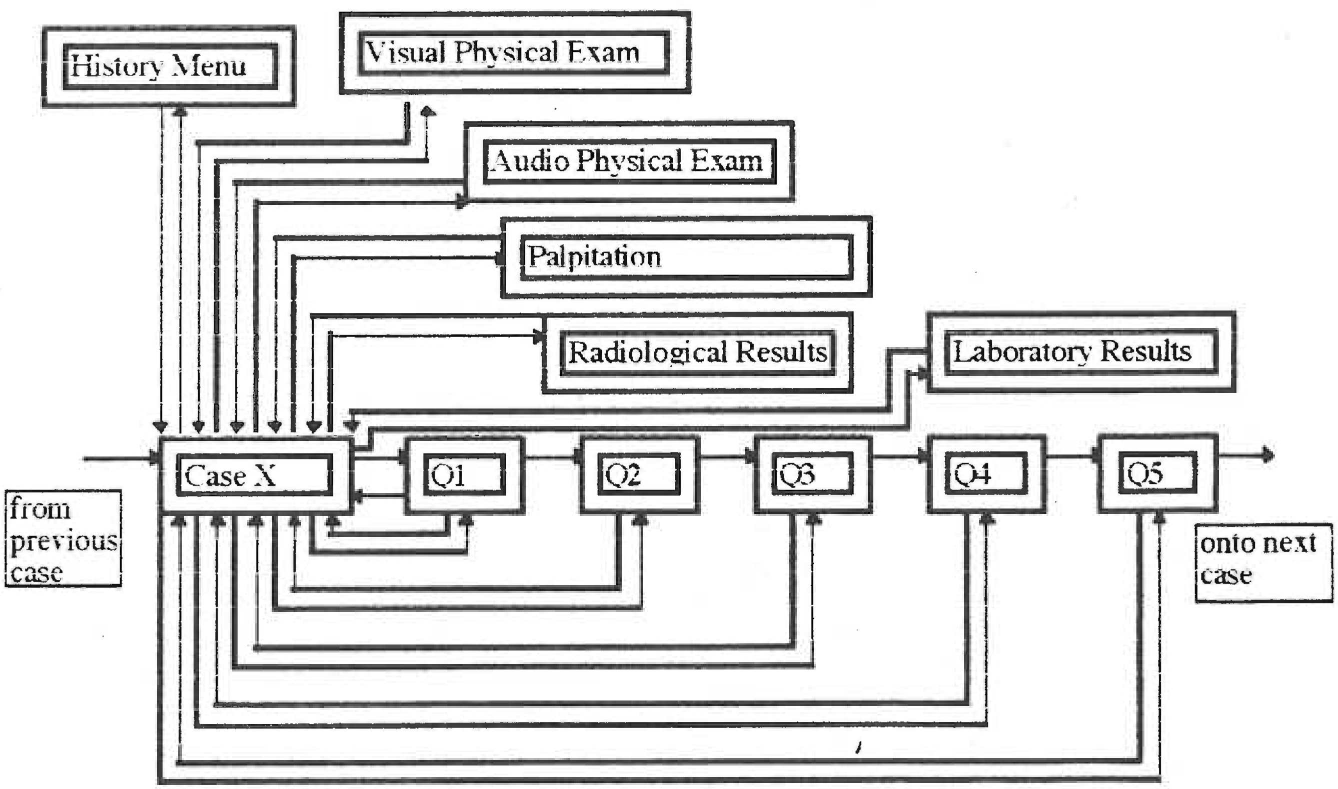

Figure 4. Schematic Diagram of Navigation of the Virtual Patient Simulator

In conjunction with this decision, it was also decided to allow subjects to change their answer while interacting with a particular question, but to not be able to return to a particular question once the subject has indicated that they wish to continue onto the next question or case scenario. By using this design strategy, subjects are able to take as much time as they feel they need in answering the questions, but are also "forced" to eventually progress through the entire simulation program.

Navigation:

In selecting the navigation aids for the programs, several different types were considered. The choices included keyboard-entry into text fields, hypertext links, buttons, draggable icons, and/or drop-down menus. A button, in this case, is defined as a stationary element on the screen that requires a mouse-click to initiate the event; the event can be either the display of additional information on the screen, restarting the playing of some multimedia element, or the movement of the subject to another screen. Draggable icons are defined as miniature pictures that are moveable, have a specific function associated with them, and are used to access additional information. The selection of which navigation aids to use was important because of their impact on the preferable program characteristics of user control, transparency, flexibility, and learnability. The selection was also important because navigation is a sources of potential bias when the simulators are recording subjects' responses and interaction times. These concerns were addressed in the following manner.

It was decided to have the programs be operated by mouse-driven actions instead of text-entry actions to avoid the bias produced by subjects' familiarity with the configuration of the keyboard and differences in typing skills. To avoid the potential confounder of previous computer skills, it was decided to use buttons instead of hypertext as navigational links; pointing and clicking on a button is often considered more intuitive for performing an action than pointing and clicking on text. In addition, the function of the buttons needs to be as conceptually easy to understand as possible. For this reason, it was decided to use buttons containing explanatory text instead of symbols since the meaning of a symbolic button could be ambiguous to the user. For purposes of clarification, however, it is worth noting that icons - symbolic mini-pictures - were used with the virtual patient simulator to facilitate the interactive access of patient information in the simulation of the clinical encounter.

Screen Layout:

The opening scenes for both simulators were designed to explain the content of the exam - 20 case scenarios each followed by a set of questions, - the actions available to the subject - return to case information, but not to a previous question or previous cases, - and to identify the subject - text-entry box in which subject could type information. The decision to provide these basic instructions and not additional ones was purposely made; this decision allows the test administrator to decide much of the information given to the subjects, including whether or not the subject would be informed of the examination recording their responses and interaction-times. For this reason, the set of instructions for using the programs only provides the minimal amount of information needed for operating them.

The graphical design of the screen layout, like the method of navigation, was important since it had to make the examinations as easy as possible for subjects to use. Remembering the design goal of transparency, it was desirable that subjects be able to focus on the case information presented to them and answering the questions related to each case, but not to have to be overly concerned with the access of different kinds of information. The screen layout also had to be designed to avoid possible unintentional actions of the user; clicking on the wrong button resulting in increased interaction time recordings, in misleading response recordings, or even unintentionally progressing onto other parts of the examination before completion of the current one. In addition, the layout design needed to be as intuitive as possible, such as making it easy for subjects to locate different icons and buttons by placing them in consistent locations and in accordance with the visual design principles of balance, regularity, economy, sequential, and proportion.

As the foundation of the layout design, all screens of both programs were designed so that the information presented on a screen would most likely be viewed first before any icons or buttons, so that subjects would be encouraged to view the information before initiating any actions through the use of the icons or buttons. Since most people view screens diagonally from the top left-hand corner to the bottom right-hand corner, all the case- and question- related information was located toward the top or left-hand side of the screen with all the buttons or icons located toward the bottom or right-hand side of the screen. Figure 5 shows a schematic diagram of the general design principle used in the layout development.

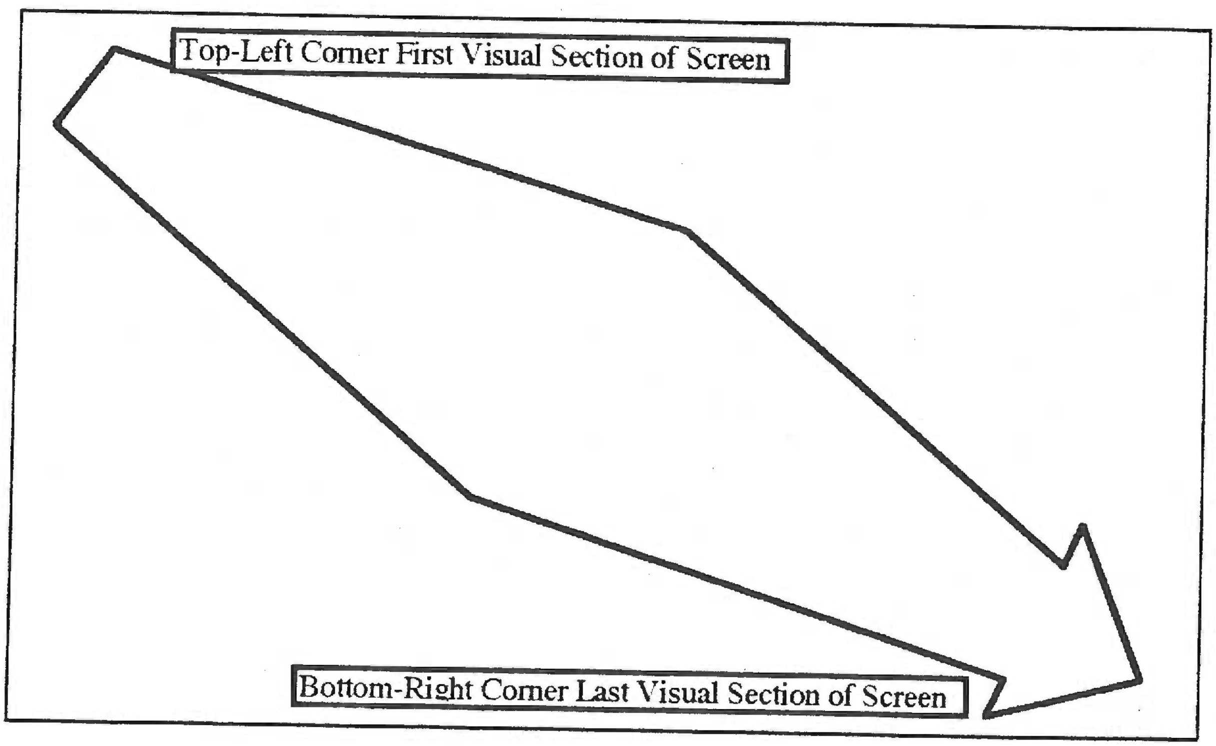

Figure 5. Schematic Diagram of the General Design Principle Used in the Layout Development

The next design strategy that was applied was to have the icons placed toward the central-bottom section of the screen and any buttons toward the bottom-right section of the screen, so that if a subject accidentally initiated an action, they would be more likely to initiate an action using an icon instead of a button. In most cases, initiating an accidental action using an icon would have less unwanted and irreparable effects than a button. such as viewing an extra or unnecessary radiological finding instead of starting the recording of a question-interaction time sequence or moving onto a new section of the exam before finishing the current one. While an icon action might be the viewing of an extra or unnecessary radiological finding, clicking a button might start the record of a questions-interaction time sequence or cause the subject to move into a new section of the examination before the current section is completed. This also fits with the logical interactive progression through most screens, where subjects would be expected to want to use the icons at the bottom portion of the screen, where they will theoretically be viewed before the buttons, which are in the bottom-right corner. Refer to figure 6 for a diagram of the general location of icons and buttons on the screen layout. In addition, on screens that only contain buttons but no icons, the button which would result in the most adverse effects if accidentally activated was placed closest to the bottom-right portion of the screen.

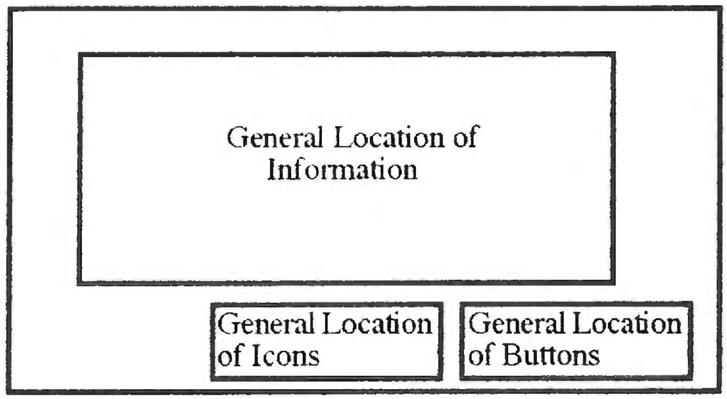

Figure 6. Diagram of General Location of Icons and Buttons on Screen Layout

The background color used in each simulator was chosen to provide enough contrast with the foreground text and pictures so that the foreground could be easily identified, but so that the contrast would not contribute to eye strain. A black background was used for video clips.

Design Considerations Specific to the Text-Based Test

Specific elements in the text-based test design are described here. Upon starting each patient case scenario, a section of text describing the general condition of the patient is provided to the subject. This initial screen is referred to as the "main patient information screen." In addition to the descriptive text, three buttons are provided, one for accessing the patient history, the second for accessing the physical examination, and the third for accessing laboratory results. Upon clicking one of these buttons, additional text is added to the main patient information screen adding the specific information to the initial general information. A fourth button for navigating the subject to the test questions is also provided. This button, when clicked, moves the subject either to the first test question, or, if the subject has previously viewed but not completed one of the test questions, then back to that question. The final screen of the text-based test gives the subject their score as percent of correct answers. Figures 7 and 8 show examples of the screen displays used in the text-based test.

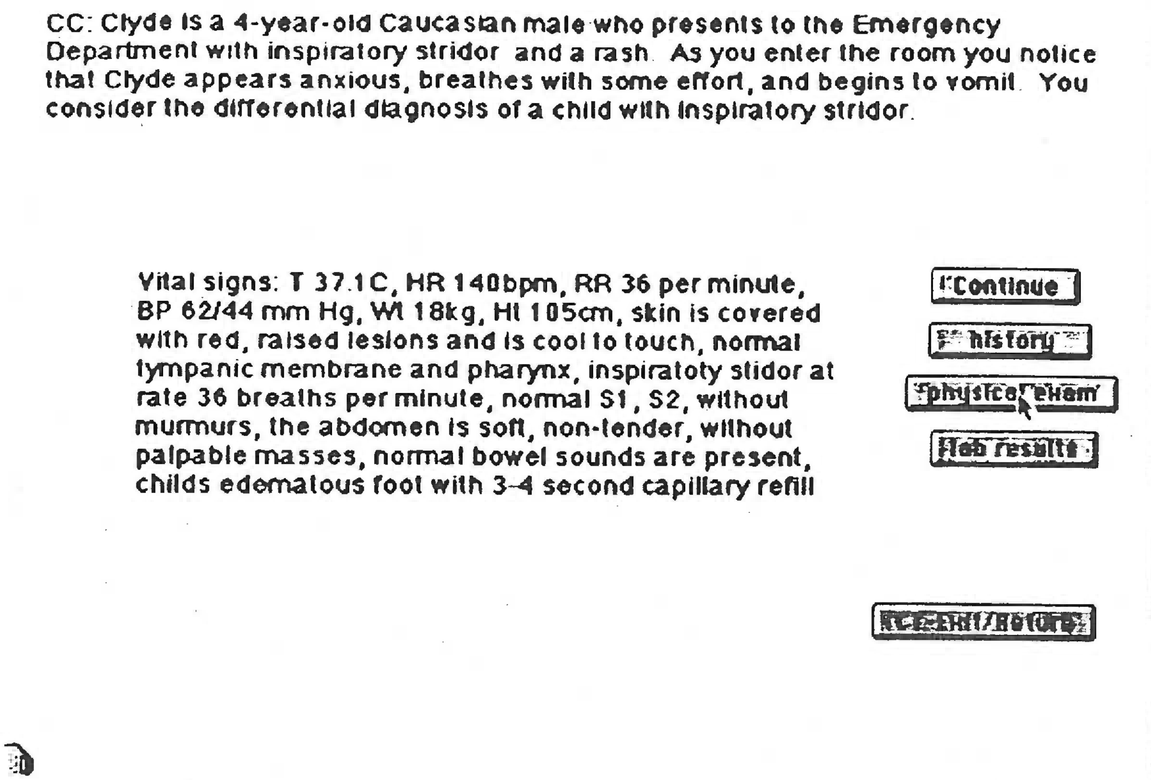

Figure 7. Example of Text-based Test Patient Case Information Screen

This screen has the initial descriptive information and added detail information resulting from clicking on the "Physical Examination" button.

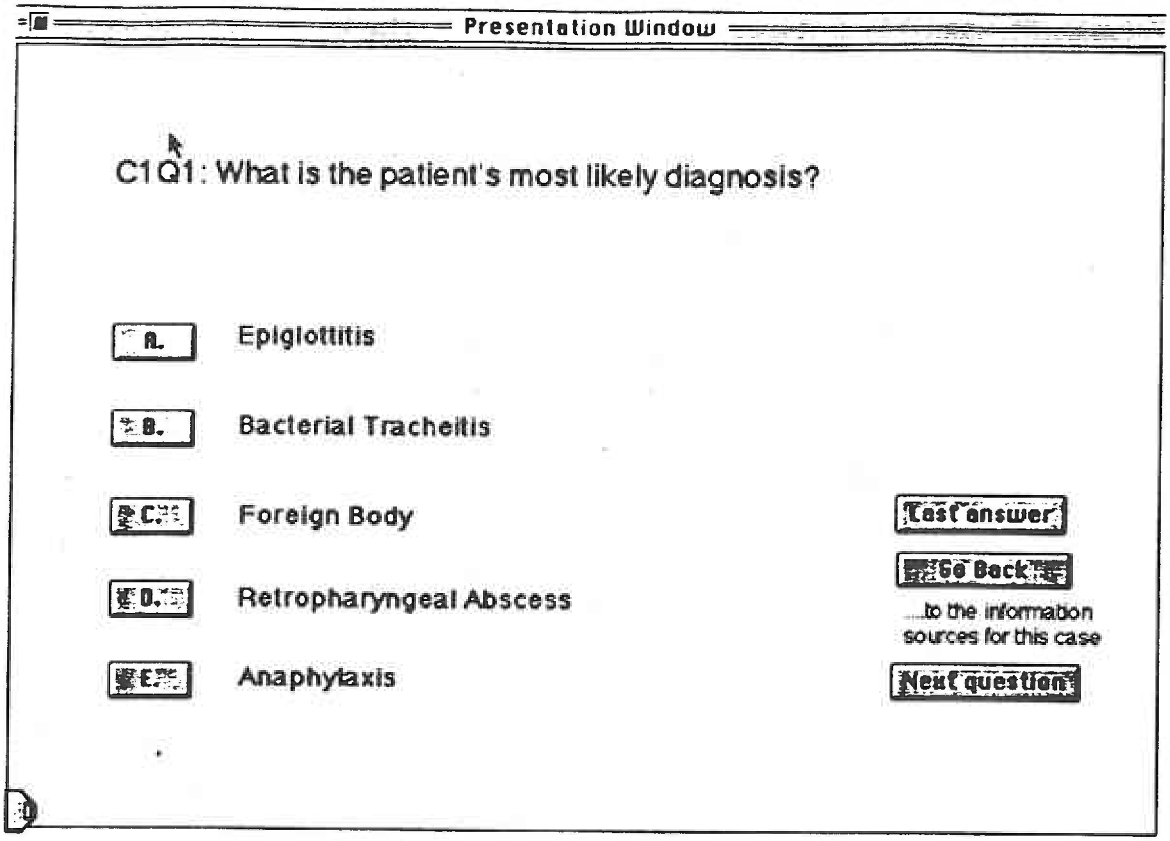

Figure 8. Example of Text-based Test Question Screen

Flow control in this examination allows the subjects to view the test questions, given a preliminary answer to the question if desired, then return to the main screen to review the clinical information. On return to the test question, the design construct was to not automatically display the preliminary answer, but rather to provide an option for viewing this information by clicking on a button labeled "Last Answer". This construct was based on the concern that a previously selected answer might be a distraction to the subject and was balanced by the potential of the subject not being able to recall their preliminary answer on return to the test question. While using radio buttons would have been a logical choice for indicating responses to questions, this was not possible since Authorware does not have radio buttons which retain the memory of a selection from one screen to another, making this planned feature difficult to implement. Because of this limitation, a graphic of an arrow was used as an indicator both for the current and previously selected answers.

Design Considerations Specific to the Virtual Patient Simulator

Specific elements in the virtual patient simulator design are described here. Unlike the text-based test that only has three buttons for accessing additional patient information, the virtual patient simulator had to be designed to provide access to more specific types of patient information in a more interactive fashion. The main patient information screen consists of a picture of the patient with a small text section containing the vital signs of the patient. Icons for accessing additional information and buttons for navigation are also provided. These tools will be discussed later in this section. A button for navigating the subject to the appropriate test question is also provided on the main patient information screen. The final screen of the virtual patient simulator gives the subject their score as percent correct.

For a series of illustrations of the screen displays used in the virtual patient simulator, refer to figures 9 - 11.

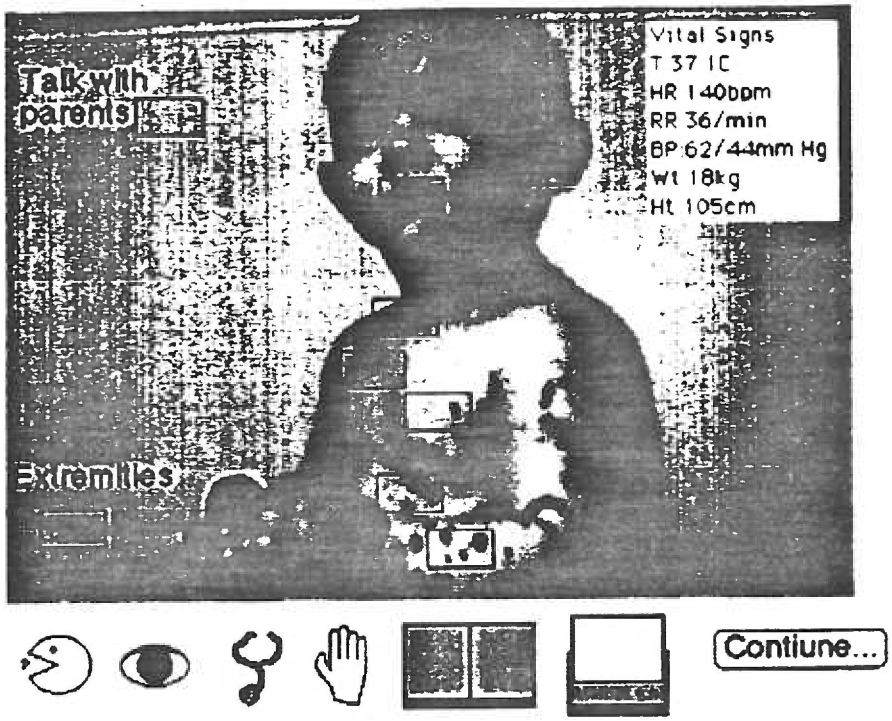

Figure 9. Main Patient Information Screen of Virtual Patient Simulator

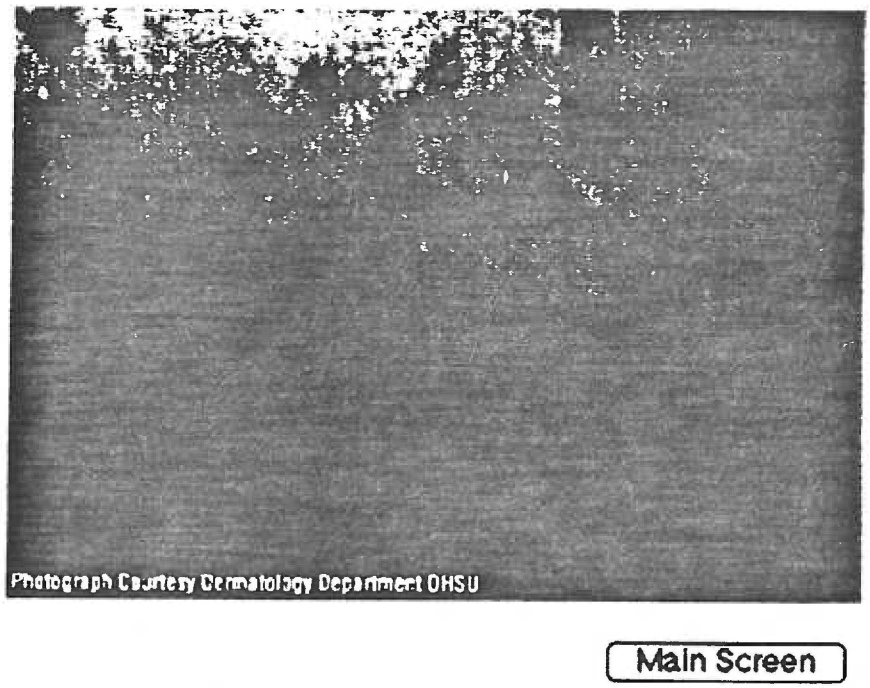

Figure 10. Example of Physical Exam Finding of Virtual Patient Simulator

This was produced when the subject drug the inspection icon over the patient's arm.

C1Q1 : What is the patient's most likely diagnosis?

- O A. Epiglottitis
- O B. Bacterial Tracheitis
- O C. Foreign Body
- O D. Retropharyngeal Abscess
- O E. Anaphylaxis

[Last Answer]

[Return...]
to case information sources

[Contiune...]
on to the next question

Figure 11. Example of Virtual Patient Simulator Test Question Screen

One of the more important design decisions made in the construction of the virtual patient simulator was how to allow subjects to access the different forms of patient information. Keeping with the design principles of graphical user interface (GUI) design, four different types of draggable icons representing the different actions of communication, viewing (inspection), listening (auscultation), and palpation were chosen to represent access to patient information. Communication is represented by a schematic diagram of a person's head with an open mouth and a question mark in front of the mouth; inspection is represented by a drawing of an eye; auscultation is represented by the picture of a stethoscope; and palpation is represented by a hand. Figure 12 illustrates the different icons used in the virtual patient simulator.

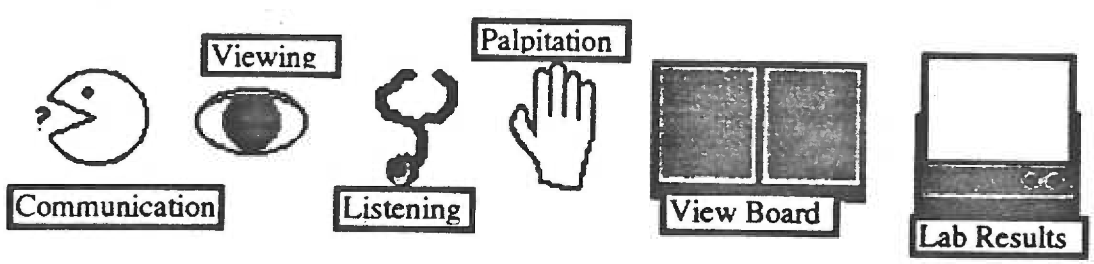

Figure 12. Draggable Icons Used in the Virtual Patient Simulator

Since programs built in Director can recognize an event as the intersection of two elements on the computer screen (in the paradigm of two "actors" meeting and interacting) a logical means of having subjects use these icons to access patient information is to have them move the icon over the body part or ancillary service for which they want more information. This event then triggers the navigation to screens displaying the specific patient information.

We now have an "actor" in the form of a draggable icon and need the "actor" on the main screen for him to interact with. For example, if a subject wants to closely examine a rash on a patient, would he or she be able to drag the inspection icon to any part of the patient's skin and get a close-up picture of the rash? As a practical solution to this challenge, it was decided that rectangular shapes would be used to specify the different sections of the computer screen that were available for initiating the transference to the more specific patient information screens. To help subjects know which rectangular shapes were associated with the different icons, the outlining color of the icon was matched to the outlining color of the appropriate rectangle. For example, the communication icon was outlined in the color red. On the main patient screen is a rectangular shape containing either the words "Talk with Parents" or "Talk with Patient" used for accessing the patient history. This rectangle also has a red border. When the red communication icon is dragged to intersect with the red rectangle, the program changes to a screen containing history questions and responses. In some cases there are several rectangles of the same color on a screen; in this case, the intersection with the same-colored icon results in a different action for each rectangle.

Drop-down menus were also used in the patient information screens. When the history, imaging and laboratory results rectangles are intersected, a drop-down menu box appears which will list either the questions which can be asked of the patient or parent, or, the list of imaging or laboratory studies which can be performed. On selection of one of the menu items, the result or answer is displayed. The answers to the history questions are presented in the form of audio clips. If only one question or study is available in a particular section, then no drop-down menu is needed and the answer or result is accessed upon the icon intersection.

The final form of a GUI selection tool used in this program is the radio button, which is used for selecting the test question answers. Unlike Authorware, Director can associate an underlying variable with the selection of a radio button. This allows the retention of a preliminary answer while the subject navigates back to the main screen in order to get more information which can then be redisplayed as a radio button if the subject clicks on the "Last Answer" button.

No time limitation was placed on the viewing of text and graphics in the virtual patient simulator. In order to address the goals of user control and transparency, a decision had to be made concerning the inclusion of a replay button on the screens presenting audio and video clips. At all times, the subjects can first return to the main screen and then renavigate back to those multimedia elements. However, this requires reloading of the multimedia elements into memory and a potentially significant time delay. However, because of technical problems associated with replaying video and audio clips without reloading them into memory, the decision was made to limit the replay capability to the video clips and not to allow replay of the audio clips. This decision is supported by the repetitiveness of most of the audio clips used in the virtual patient simulator. Unlike video clips, most of the audio clips that are not part of a "drop-down" menu are long and repetitive enough for subjects to gain whatever information they can without having to replay the audio clips. However, subjects do have the option of returning to the main patient information screen and reactivating a given audio clip if they so desire. For those audio clips which are not repetitive, such as responses to history questions, these can be quickly reaccessed by their drop-down menu option. Based on this reasoning it did not seem necessary to include replay buttons on audio clip screens.

Evaluation Tools:

These examinations capture, for each test subject, the answers to the 100 test questions as well as the total number of and percentage of correct responses. It is this total number of correct answers that was used as the result for the pilot testing in this project and is the primary measurement that will be used in the future research projects for which these computerized examinations were designed. These programs, however, collect several other types of results. The other kinds of results that are collected are as follows:

- the interaction time for each question - recorded from the initial viewing of a question to the progression onto either a new question or a new case;
- the subject's sequential navigation through the program - including the order of clinical information accessed; and
- preliminary answers to test questions - any answers they selected prior to their final selection.

The number of correctly answered questions is calculated as a percentage for comparing results among and between program subjects. The question interaction times identify whether or not subjects are spending more time on one question than another. While subjects may spend more time on a particular question because they don't know the answer, it is also possible that flaws in the program design are at fault. The subject's sequential navigation through the program is useful for determining what clinical information the subjects feel that they need to answer a given case's questions and ultimately in tracing the subjects' thinking. The tracking of preliminary question responses is beneficial in identifying sources of potential confusion, whether having to do with the clinical information, the questions, or the design of the program.

Several other methods of analyzing the results are possible given the types of information recorded by both programs; these methods might be useful if the programs are used, not for research as designed, but in actual student testing. For instance, the average number of correctly answered questions for each case can be calculated and used in determining which, if any, cases seem to be especially difficult for subjects. In another possible analytical use, the subjects' interaction times as recorded for each examination might be useful in determining whether or not longer times spent interacting with the cases leads to better test scores, or in determining which type of questions the subjects take the most time in answering. The numerous ways in which the data can be analyzed are due to the large amount and different types of information that are recorded for each testing session.

PILOT TESTING OF THE DEVELOPED EXAMINATIONS

After completion of the initial development phase, the examinations were tested by administering them to a small number of medical students. Four students were tested, all of whom were third year medical students completing a pediatrics rotation. All subjects were familiar with computers and used them on a regular basis, but none would, by their description, be considered "superusers". Prior experience for all subjects included the use of a hospital results reporting system and use of computerized library resources.

Three of the students took only one of the examinations (two took the text-based test and one the virtual patient simulator). The fourth student took both examinations. While normal test situations were not stringently reproduced, the method of administering the tests approximates the normal setting enough to suggest reliability of the results of this early testing: the students individually took the tests in a faculty office, each test was taken in one uninterrupted sitting but without time restrictions, and supervision was provided to handle technical problems but no assistance with clinical questions was available. After the completion of the test, each subject was questioned about his or her impression of the test overall and for any specific questions he or she might have for revision of the test.

Results

A sample of the raw data from the pilot test results for this project are provided in the section of this paper labeled, "Appendix A: Raw Data". Overall test scores are shown in Table 1 as the percentage of correct answers. Results are reported for 19 of the 20 cases tests as there was a technical problem with one of the cases in the virtual patient simulator. The average test score for the text-based test was 83% and for the virtual patient simulator was 80%. Table 2 shows the average number of correct answers by case and examination. The purpose of this analysis is to look for "hotspots" that might indicate problems with the examinations. As noted, there was clearly a problem with Case 7 on the virtual patient simulator.

Type of Program : Subject	Total Score : Percentage Correct
Text-based : Subject 1	81 : 85.3%
Text-based : Subject 2	77 : 81.0%
Text-based : Subject 3	76 : 80.0%
Virtual Patient : Subject 3	74 : 77.9%
Virtual Patient : Subject 4	77: 81.0%

Table 1. Percent of Correct Answers (Excluding Case 7)

Case Number	Text-based Test Ave. Correct	Virtual Patient Test Ave. Correct
1	4.7	4.0
2	3.3	3.0
3	4.7	4.5
4	4.0	4.0
5	4.3	0.5
6	5.0	3.0
8	4.3	5.0
9	3.0	4.0
10	5.0	5.0
11	4.3	4.0
12	4.0	4.5
13	4.0	4.5
14	4.7	4.5
15	3.7	4.0
16	3.0	4.5
17	4.0	4.5
18	3.7	3.0
19	4.0	3.0
20	4.7	5.0

Table 2. Average Correct Answers for Each Case
Each case had test five questions.

Subjects offered several useful comments. They suggested that the age of the patient should be stated or accessible. They thought that the history questions were not broad enough and would have liked to have been able to ask other questions. In some cases more imaging studies would have been requested. It was also suggested that the "Replay" button be available for use with the audio clips. There was a request that the lab results be displayed differently in the format of columns. Overall, however, the interfaces were felt to be easy to learn and to use. The subjects easily understood how to access the different types of information. One subject thought that simulators are better used for training than for testing.

CONCLUSIONS

Were the design goals met?

Two examinations covering the evaluation and initial management of pediatric patients were developed in this project. They were tested successfully with the exception of a technical problem with one case in one of the examinations. As a measure of that success, they recorded results of the examination in a way that is needed for future studies, they recorded additional results that could be used for other evaluations, and they have the quantitative and qualitative characteristics that were desired at the initiation of the project. In particular, they met the qualitative goal of user control by allowing bidirection navigation and replay except where noted to facilitate the completion of the examination and to avoid reload problems. The qualitative goal of transparency was demonstrated by the reports of the subjects that the interfaces did not require significant learning prior to use. The characteristic of flexibility was accomplished by the inclusion of measurement paraments allowing the results to be used in more than was originally planned. The learnability of the prgograms is evidenced by the subjects' ease of performing the basic activities without complex instructions.

The quantitative criteria of reliability is marred only by the one case presenting technical difficulties. The exact cause of this difficulty has not yet been determined, although this author is suspicious that it is related to the memory requirements of this media-intensive program. The criteria of maintainability has been met by the modular design and the ease with which the programming code can be read and edited. The critieria of modifiability is demonstrated by the ability to customize the cases and questions as required by study methodology. The criteria of efficiency perhaps needs further evaluation based on results of the examination of computer memory requirements. This test can be used on a desktop computer, however, not requiring excessive resources for operation. Overall the usability was demonstrated in the pilot project.

The Next Iteration and Future Directions

Before commencing the second cycle of the design process for this development project, this author would try to address certain issues, such as memory requirements, portability of the programs, and refinement of the content. Once these concerns have been addressed and the development phase of the project completed, then the examinations could be used as planned for determining if and why any differences in the programs exist.

BIBLIOGRAPHY

Bergston BA. Computerized adaptive testing for the national certification examination. AANA Journal 1996;64:119-124.

Bersky AK, Yocum CJ. Computerized clinical simulation testing: its use for competence assessment in nursing. Nursing and Health Care 1994;15:120-127

Cavanaugh S. Computer simulation technology for clinical teaching and testing. Academic Emergency Medicine 1997;4:939-943.

Chapman DM, Marx JA, Honigman B, Rosen P, Cavanaugh SH. Emergency thoracotomy: comparison of medical student, resident, and faculty performances on written, computer, and animal-model assessments. Academic Emergency Medicine 1994;1:373-381.

Chopra V, Gesink BJ, de Long J, Bovill JG, Spierdijk J, Brand R. Does training on an anesthesia simulator lead to improvement in performance?. British Journal of Anesthesia 1994;73:293-297.

Clauser BE, Raja GS, Piemme TE, Greenberg L, Clyman SG, Ripkey D, Nungester RJ. Using clinician ratings to model score weights for a computer-based clinical-simulation examination. Academic Medicine 1993;68:564-566.

Clayden G. Writing and marking examinations for paediatrics. Medical Education 1996;74:469-473.

Cox K, Walker D. User Interface Design. Singapore: Prentice Hall, 1993.

Forker JE, McDonald ME. Methodologic trends in the healthcare professions: computer adaptive and computer simulation testing. Nurse Educator 1996;21:13-14.

Holden GW, Klinger AM. Learning from experience: differences in how novice vs. expert nurses diagnose why and infant is crying. Journal of Nursing Education 1988;27:23-29.

Hubbard JP, Levit EJ, Schumacher CF, Schnabel TG. An objective evaluation of clinical competence: new techniques used by the National Board of Medical Examiners. NEJM 1965;272:1321-1328.

Keels M, Dear G. Computer-based evaluation of pediatric dental residents' clinical performance. Pediatric Dentistry 1996;18:74-75.

Malakoff G, Pincetl PS, El-Bayoumi J, Chang L, Piemme TE. Computer-based patient simulations and their effect on standardized-test scores during a medicine clerkship. Academic Medicine 1994;69:155

Ohrn MA, van Oostrom JH, van Meurs WL. A comparison of traditional textbook and interactive computer learning of neuromuscular block. Anesthesia and Analgesia 1997;84:657-661.

Okasha A. The future of medical education and teaching: a psychiatric perspective. Am J Psychiatry 1997;154:77-81.

Roberts JD, While AE, Fitzpatrick JM. Clinical problem-solving using video simulation: an investigation. Medical Education 1995;29:347-354.

Schuwirth L, Vleuten C, Stoffers H, Peperkamp A. Computerized long-menu questions as an alternative to open ended questions in computerized assessment. Medical Education 1996;30:51-56.

Stempczynska J, Kacki E. STUD2 system for computer assistance in oncology education. IMIA 1995;MEDINFO 95 Proceedings:1233-1236.

Takabayashi K, Fujikawa K, Suzuki T, Yamazaki S, Honda M, Amaral M, Satomura Y, Yoshida S, Tomioka H. Implementation and evaluation of computerized patient management problems. IMIA 1995; MEDINFO 95 Proceedings:1218-1221.

Verma M, Singh T. Attitudes of medical students towards objective structured clinical examination (osce) in pediatrics. Medical Education 1993;10:1259-1261.

Weiner EE, Gordon JS, Gilman BR. Evaluation of a labor and delivery videodisc simulation. Computers in Nursing 1993;11:191-196.

Wesley L, Ault H, Kirk JS, Comstock CH. Interactive multimedia for prenatal ultrasound training. Obstetrics and Gynecology 1995;85:135-140.

While AE. Competence versus performance: which is more important?. Journal of Advanced Nursing 1994;20:525-531.

Williams T, Giuse N, Huber J, Janco R. Cross-platform hypermedia examinations on the web. AMIA 1995; :498-501.

Wofford JL, Wofford MM. The multimedia computer for case simulation: survival tool for the clinical educator. M.D. Computing 1997;14:88-93.

Yourdon E, Constantine T. Structured Design. Englewood Cliffs, NJ: Prentice Hall, 1979

Zaglaniczny KL. The transition of the national certification examination from paper and pencil to computer adaptive testing. AANA Journal 1996;64:9-14.

APPENDIX A:

Raw Data

Text-Based Simulator Results

User Name/ID: kate Score: 84

c1q1: 1hx-pe-lr-E. c1q2: 1C. c1q3: 1B. c1q4: 1D. c1q5: 1D.
c1q1-c1q5 time: .367 .567 .466 .25 .35
c2q1: 0hx-pe-lr-A.B. c2q2: 0D. c2q3: 1C. c2q4: 1A. c2q5: 1D.
c2q1-c2q5 time: 3.198 .35 .367 .25 .367
c3q1: 1hx-pe-lr-lr-B. c3q2: 0C. c3q3: 1A. c3q4: 1D. c3q5: 1hx-C.
c3q1-c3q5 time: 2.55 .3 .266 .234 .7
c4q1: 1hx-pe-lr-E. c4q2: 0A. c4q3: 1C. c4q4: 1E. c4q5: 1B.
c4q1-c4q5 time: 2.151 .25 .266 .15 .467
c5q1: 1hx-pe-lr-B. c5q2: 1E. c5q3: 1B. c5q4: 1D. c5q5: 1A.
c5q1-c5q5 time: 2.15 .25 .333 .133 .15
c6q1: 1hx-pe-lr-C. c6q2: 1A.E. c6q3: 1C. c6q4: 1lr-B. c6q5: 1A.
c6q1-c6q5 time: 1.718 .517 .15 .834 .3
c7q1: 1hx-pe-lr-C. c7q2: 0A. c7q3: 0 c7q4: 1D. c1q5: 1A.
c7q1-c7q5 time: 1.867 .267 0 .4 .133
c8q1: 1hx-pe-lr-pe-hx-A. c8q2: 1E.E. c8q3: 1D. c8q4: 1lr-B. c8q5: 1D.C.
c8q1-c8q5 time: 3.198 .584 .15 1.084 .083
c9q1: 1hx-pe-lr-lr-B. c9q2: 0E.E. c9q3: 1B. c9q4: 0B. c9q5: 1E.D.
c9q1-c9q5 time: 2.932 .3 .284 .25 .367
c10q1: 1hx-pe-lr-A. c10q2: 1C.A. c10q3: 1D. c10q4: 1C.E. c10q5: 1B.
c10q1-c10q5 time: 2.084 .15 .284 .15 .167
c11q1: 1hx-pe-lr-D. c11q2: 1C. c11q3: 1D. c11q4: 1D. c11q5: 1A.
c11q1-c11q5 time: 1.834 .25 .15 .166 .283
c12q1: 1hx-pe-lr-C. c12q2: 0D. c12q3: 1C. c12q4: 1A. c12q5: 1E.
c12q1-c12q5 time: 1.9 .267 .166 .366 .317
c13q1: 1hx-pe-lr-D. c13q2: 0E. c13q3: 1C. c13q4: 1E. c13q5: 1B.
c13q1-c13q5 time: 2.183 .333 .366 .267 .266
c14q1: 1hx-pe-lr-D. c14q2: 1A. c14q3: 1D. c14q4: 1A. c14q5: 1B.
c14q1-c14q5 time: 2.067 .2 .216 .25 .283
c15q1: 1hx-pe-lr-pe-hx-lr-pe-C. c15q2: 1E. c15q3: 1C. c15q4: 1lr-E. c15q5: 1B.
c15q1-c15q5 time: 3.633 .15 .166 1.383 .167
c16q1: 1hx-pe-lr-C. c16q2: 1D. c16q3: 1E. c16q4: 1A. c16q5: 0D.
c16q1-c16q5 time: 1.685 .15 .183 .216 .284
c17q1: 1hx-pe-lr-pe-C. c17q2: 1D. c17q3: 1C. c17q4: 0lr-E. c17q5: 1C.
c17q1-c17q5 time: 2.632 .25 .367 1.382 .333
c18q1: 1hx-pe-lr-C. c18q2: 0B. c18q3: 0B. c18q4: 0lr-D. c18q5: 1
c18q1-c18q5 time: 2.283 .166 .25 1.583 .3
c19q1: 1hx-pe-lr-pe-hx-lr-B. c19q2: 1 c19q3: 1C. c19q4: 0lr-E. c19q5: 1
c19q1-c19q5 time: 3.617 .25 .25 1.133 .167
c20q1: 1hx-pe-lr-E. c20q2: 1 c20q3: 1A. c20q4: 1 c20q5: 1B.
c20q1-c20q5 time: 1.8 .3 .167 .55 .334

User Name/ID: jackinthebox Score: 81

c1q1: 1hx-pe-lr-hx-lr-E. c1q2: 0lr-pe-D. c1q3: 1B. c1q4: 1lr-D. c1q5: 1D.hx-D.

c1q1-c1q5 time: 1.133 1.051 .15 .916 .984

c2q1: 1hx-pe-lr-pe-lr-A. c2q2: 0D. c2q3: 1lr-C. c2q4: 1A. c2q5: 1D.hx-D.

c2q1-c2q5 time: 2.75 .167 .867 .15 .884

c3q1: 1hx-pe-lr-lr-B. c3q2: 1lr-pe-E. c3q3: 1A. c3q4: 1D. c3q5: 1C.

c3q1-c3q5 time: 1.883 1.116 .15 .167 .15

c4q1: 1hx-lr-pe-E. c4q2: 0A.A. c4q3: 1C. c4q4: 1E. c4q5: 1B.

c4q1-c4q5 time: 1.417 .767 .3 .15 .166

c5q1: 1hx-pe-lr-pe-lr-B. c5q2: 1E. c5q3: 1pe-A.B. c5q4: 1lr-D. c5q5: 1A.

c5q1-c5q5 time: 2.034 .2 .983 .885 .334

c6q1: 1hx-pe-lr-C. c6q2: 1lr-E. c6q3: 1C. c6q4: 1B. c6q5: 1A.

c6q1-c6q5 time: 1.368 .95 .183 .133 .15

c7q1: 1hx-hx-pe-lr-lr-C. c7q2: 0pe-lr-B. c7q3: 1pe-lr-hx-B. c7q4: 1D. c1q5: 1hx-A.

c7q1-c7q5 time: 2.482 .999 1.834 .167 1.35

c8q1: 0hx-pe-pe-lr-hx-pe-lr-C. c8q2: 1E. c8q3: 1lr-D. c8q4: 0lr-C. c8q5: 1D.hx-D.C.

c8q1-c8q5 time: 4.185 .833 1.134 .899 1.449

c9q1: 1hx-pe-lr-B. c9q2: 0A.E.A.E. c9q3: 1hx-hx-lr-B. c9q4: 0B. c9q5: 1E.D.

c9q1-c9q5 time: 1.767 .533 1.617 .167 .267

c10q1: 1hx-pe-lr-A. c10q2: 1C. c10q3: 1D. c10q4: 1C.E. c10q5: 1B.

c10q1-c10q5 time: 1.45 .25 .183 .15 .25

c11q1: 0hx-pe-lr-B.B.D.pe-lr-B. c11q2: 0E. c11q3: 1D. c11q4: 1D. c11q5: 1A.

c11q1-c11q5 time: 2.732 .267 .2 .266 .067

c12q1: 1hx-pe-lr-C. c12q2: 0D. c12q3: 1C. c12q4: 1A. c12q5: 1E.

c12q1-c12q5 time: 1.517 .083 .2 .4 .067

c13q1: 1hx-pe-lr-D. c13q2: 0E.hx-E. c13q3: 1C. c13q4: 1E. c13q5: 1B.

c13q1-c13q5 time: 1.5 1.384 .167 .15 .167

c14q1: 1hx-pe-lr-D. c14q2: 1A. c14q3: 1lr-D. c14q4: 1A. c14q5: 0hx-E.

c14q1-c14q5 time: 1.4 .133 .784 .133 .682

c15q1: 0hx-pe-lr-hx-hx-pe-lr-D. c15q2: 1E. c15q3: 0D.B.pe-lr-D. c15q4: 1lr-E. c15q5: 1B.

c15q1-c15q5 time: 3.284 .15 1.318 1.049 .25

c16q1: 0hx-pe-lr-E. c16q2: 1D. c16q3: 0C. c16q4: 1A. c16q5: 1A.

c16q1-c16q5 time: 1.251 .317 .167 .25 .067

c17q1: 1hx-pe-lr-C. c17q2: 1D. c17q3: 1B.C. c17q4: 1lr-pe-B. c17q5: 1C.

c17q1-c17q5 time: 1.801 .25 .516 1.2 .15

c18q1: 1hx-pe-lr-C. c18q2: 0B. c18q3: 1E. c18q4: 1lr-C.lr-E. c18q5: 1

c18q1-c18q5 time: 1.584 .05 .2 1.599 .4

c19q1: 1hx-pe-lr-B. c19q2: 1C.hx- c19q3: 1C.pe-lr- c19q4: 1lr-E.A. c19q5: 1

c19q1-c19q5 time: 2.551 .949 1.102 1.052 .15

c20q1: 1hx-pe-lr-E. c20q2: 0D. c20q3: 1lr-A. c20q4: 1 c20q5: 1B.

c20q1-c20q5 time: 1.251 .283 .783 .167 .133

User Name/ID: debra Score: 78

c1q1: 1hx-pe-lr-E. c1q2: 1C. c1q3: 1B. c1q4: 1D. c1q5: 1D.
c1q1-c1q5 time: .184 .15 .367 .167 .15
c2q1: 1hx-pe-lr-A. c2q2: 0C. c2q3: 1C. c2q4: 1A. c2q5: 0A.
c2q1-c2q5 time: 1.35 .183 .25 .15 .15
c3q1: 1hx-pe-lr-lr-B. c3q2: 1E. c3q3: 1A. c3q4: 1D. c3q5: 1C.
c3q1-c3q5 time: 1.902 .184 .133 .183 .167
c4q1: 0hx-pe-lr-lr-pe-lr-D. c4q2: 1B.D. c4q3: 1hx-pe-hx-pe-lr-C. c4q4: 1E. c4q5: 1B.
c4q1-c4q5 time: 3.001 .201 2.518 .15 .05
c5q1: 1hx-pe-lr-B. c5q2: 0A. c5q3: 0A. c5q4: 1D. c5q5: 1A.
c5q1-c5q5 time: 1.215 .134 .216 .05 .15
c6q1: 1hx-pe-lr-C. c6q2: 1E. c6q3: 1C. c6q4: 1B. c6q5: 1A.
c6q1-c6q5 time: 1 .167 .067 .317 .267
c7q1: 1hx-pe-lr-C. c7q2: 0B.E. c7q3: 0C. c7q4: 1D. c1q5: 0C.
c7q1-c7q5 time: 1.616 .133 .184 .084 .267
c8q1: 1hx-pe-lr-A. c8q2: 1E. c8q3: 1D. c8q4: 1B. c8q5: 1D.C.
c8q1-c8q5 time: 1.016 .05 .15 .166 .15
c9q1: 1hx-pe-lr-B. c9q2: 0A. c9q3: 1B. c9q4: 0B. c9q5: 1E.D.
c9q1-c9q5 time: 1.619 .2 .15 .15 .2
c10q1: 1hx-pe-lr-A. c10q2: 1C.A. c10q3: 1D. c10q4: 1C.E. c10q5: 1B.
c10q1-c10q5 time: 1.285 .184 .167 .166 .15
c11q1: 1hx-pe-lr-D. c11q2: 0E. c11q3: 1D. c11q4: 1D. c11q5: 1A.
c11q1-c11q5 time: 1.149 .267 .183 .15 .05
c12q1: 1hx-pe-lr-C. c12q2: 0D. c12q3: 1C. c12q4: 1A. c12q5: 1E.
c12q1-c12q5 time: 1.2 .184 .066 .166 .15
c13q1: 1hx-pe-lr-D. c13q2: 0E. c13q3: 1C. c13q4: 1E. c13q5: 1B.
c13q1-c13q5 time: 1.367 .15 .15 .166 .15
c14q1: 1hx-pe-lr-D. c14q2: 1A. c14q3: 1D. c14q4: 1A. c14q5: 1B.
c14q1-c14q5 time: 1.432 .25 .067 .166 .133
c15q1: 1hx-pe-lr-C. c15q2: 1E. c15q3: 0B. c15q4: 0C. c15q5: 1B.
c15q1-c15q5 time: 1.383 .134 .117 .15 .167
c16q1: 0hx-pe-lr-E. c16q2: 1A.D. c16q3: 0C. c16q4: 1A. c16q5: 0D.
c16q1-c16q5 time: 1.55 .2 .267 .15 .15
c17q1: 1hx-pe-lr-C. c17q2: 0 c17q3: 0B. c17q4: 1B. c17q5: 1C.
c17q1-c17q5 time: 1.115 .15 .133 .2 .15
c18q1: 1hx-pe-lr-C. c18q2: 1A. c18q3: 1E. c18q4: 1E. c18q5: 1
c18q1-c18q5 time: 1.415 .267 .067 .15 .167
c19q1: 1hx-pe-lr-pe-hx-B. c19q2: 0C. c19q3: 0E. c19q4: 1A. c19q5: 1
c19q1-c19q5 time: 2.353 .15 .266 .167 .133
c20q1: 1hx-pe-lr-E. c20q2: 1 c20q3: 1A. c20q4: 1 c20q5: 1B.
c20q1-c20q5 time: 1.516 .05 .167 .167 .166

Virtual Patient Simulator Results

Name: debra Score: 74 c1q1: hx-pe.chest-pe.heart-pe.chest-pe.skin-pe.pharynx-pe.palpate-pe.skin-lab.images-lab.test-E.1 c1q2: C.1 c1q3: B.1 c1q4: C. c1q5: D.1 c1times: 11 74 22 76 7 ...c2q1: hx-pe.palpate-pe.rectal-A.1 c2q2: B.B.B.C. c2q3: C.1 c2q4: A.1 c2q5: A. c2times: 5 36 43 56 82 ...c3q1: hx-pe.rtchest-pe.skin-lab.test-lab.test-lab.images-B.1 c3q2: C. c3q3: A.1 c3q4: D.1 c3q5: C.1 c3times: 10 8 17 38 18 ...c4q1: hx-pe.chest-pe.stomach-lab.test-pe.neuro- c4q2: D.1 c4q3: C.1 c4q4: E.1 c4q5: B.1 c4times: 5 10 54 10 9 ...c5q1: hx-pe.head-hx-pe.heart-lab.images-lab.test-A. c5q2: D. c5q3: A. c5q4: D. c5q5: C. c5times: 27 14 29 11 21 ...c6q1: hx-pe.general-pe.chest-pe.heart-pe.stomach-C.1 c6q2: c6q3: C.1 c6q4: B. c6q5: A.1 c6times: 4 5 10 17 4 ...c7q1: hx-pe.chest-pe.neuro-pe.pulseO-pe.general-lab.test-E. c7q2: B. c7q3: C. c7q4: A. c7q5: C. c8times: 5 9 18 9 7 ...c8q1: hx-pe.skin-pe.eye-pe.stomach-lab.test-lab.images-A.1 c8q2: E.1 c8q3: D.1 c8q4: B.1 c8q5: D.1 c8times: 5 9 18 9 7 ...c9q1: hx-pe.pulseO-pe.general-pe.ear-pe.rtchest-pe.ltchest-pe.ltchest-pe.heart-pe.stomach-lab.images-lab.test-B.1 c9q2: D.E. c9q3: B.1 c9q4: B.1 c9q5: E.1 c9times: 5 25 44 10 7 ...c10q1: hx-pe.stomach-pe.gyn-lab.test-A.1 c10q2: C.1 c10q3: D.1 c10q4: C.1 c10q5: B.1 c10times: 8 4 12 12 6 ...c11q1: hx-pe.extrem-pe.skin-pe.neuro-pe.eye-pe.head-pe.stomach-pe.stomach-lab.images-lab.test-D.1 c11q2: E.A. c11q3: D.1 c11q4: D.1 c11q5: A.1 c11times: 4 24 10 9 9 ...c12q1: hx-pe.skin-pe.chest-pe.heart-pe.heart-pe.pulseO-lab.test-lab.test-lab.images-C.1 c12q2: D. c12q3: C.1 c12q4: A.1 c12q5: E.1 c12times: 8 7 16 5 6 ...c13q1: hx-pe.neuro-pe.skin-pe.eye-pe.heart-pe.stomach-lab.test-D.1 c13q2: C. c13q3: C.1 c13q4: E.E.1 c13q5: B.1 c13times: 7 18 19 10 11 ...c14q1: hx-pe.extrem-pe.neuro-pe.back-lab.images-lab.test-E. c14q2: A.1 c14q3: D.1 c14q4: A.1 c14q5: B.1 c14times: 6 6 7 8 10 ...c15q1: C.1 c15q2: E.1 c15q3: C.1 c15q4: C. c15q5: B.1 c15times: 3 6 21 19 13 ...c16q1: hx-pe.skin-pe.gen-pe.stomach-pe.heart-lab.images-lab.test-C.1 c16q2: D.1 c16q3: E.1 c16q4: A.1 c16q5: E. c16times: 11 5 19 6 18 ...c17q1: hx-pe.general-pe.pulseO-lab.test-C.1 c17q2: D.1 c17q3: lab.images-B. c17q4: B.1 c17q5: C.1 c17times: 24 7 83 6 7 ...c18q1: hx-pe.reflexes-pe.mouth-pe.hairline-pe.eye-pe.arms-lab.test-C.1 c18q2: A.1 c18q3: E.1 c18q4: E.1 c18q5: C.1 c18times: 4 5 10 10 6 ...c19q1: hx-pe.mouth-pe.chest-pe.heart-lab.test-lab.images-pe.general-pe.mouth-B.1 c19q2: C. c19q3: E. c19q4: A.1 c19q5: D.1 c19times: 10 10 59 9 7 ...c20q1: hx-pe.stomach-pe.heart-pe.chest-pe.heart-pe.chest-pe.heart-pe.ear-lab.images-lab.test-E.1 c20q2: A.1 c20q3: A.1 c20q4: E.1 c20q5: B.1 c20times: 10 7 15 34 9 ...

Name: jaime Score: 77 c1q1: hx-hx-pe.extremt-pe.skin-pe.pharynx-pe.ear-pe.heart-pe.upperchest-pe.chest-pe.upperchest-pe.chest-pe.upperchest-pe.palpate-lab.images-lab.test-E.1 c1q2: D. c1q3: B.1 c1q4: lab.images-D.1 c1q5: D.1 c1times: 35 45 49 6 6 ...c2q1: hx-pe.hip-pe.ear-pe.pharynx-pe.heart-pe.upperchest-pe.palpate-pe.rectal-lab.images-lab.test-A.A.1 c2q2: lab.test-D. c2q3: C.1 c2q4: lab.test-lab.images-pe.rectal-lab.test-A.1 c2q5: hx-A. c2times: 27 84 117 215 270 ...c3q1: hx-hx-pe.skin-pe.pharynx-pe.ear-pe.ltchest-pe.heart-pe.rtchest-lab.images-pe.palpate-lab.images-lab.test-B.1 c3q2: E.1 c3q3: A.1 c3q4: D.1 c3q5: C.1 c3times: 672 13 27 8 13 ...c4q1: hx-pe.eye-pe.mouth-pe.ear-pe.neuro-pe.skin-pe.rectal-pe.stomach-pe.heart-pe.chest-lab.images-lab.test-lab.test-lab.test- c4q2: D.1 c4q3: C.1 c4q4: E.1 c4q5: B.1 c4times: 83 17 37 9 7 ...c5q1: hx-pe.pharynx-pe.eye-pe.ear-pe.general-pe.stomach-pe.skin-pe.stomach-pe.heart-pe.chest-lab.images-lab.test-lab.images-A.B.1 c5q2: D. c5q3: lab.images-A. c5q4: D. c5q5: hx- c5times: 68 42 97 8 103 ...c6q1: hx-pe.general-pe.mouth-pe.neuro-pe.stomach-pe.heart-pe.chest-lab.test-lab.images-C.1 c6q2: c6q3: C.1 c6q4: lab.test-D. c6q5: A.1 c6times: 503 7 16 48 15 ...c7q1: c7q2: c7q3: c7q4: c7q5: c8times: 10 28 14 8 35 ...c8q1: hx-pe.pulseO-pe.general-pe.skin-pe.neuro-pe.chest-hx-pe.eye-pe.mouth-pe.skin-pe.neuro-pe.stomach-pe.heart-pe.chest-lab.test-lab.images-A.1 c8q2: E.1 c8q3: D.1 c8q4: B.1 c8q5: D.1 c8times: 10 28 14 8 35 ...c9q1: hx-pe.pulseO-pe.general-pe.neuro-pe.mouth-pe.eye-pe.ear-pe.mouth-pe.extrem-pe.stomach-pe.ltchest-pe.heart-pe.rtchest-pe.ltchest-pe.heart-pe.rtchest-lab.test-lab.images-B.1 c9q2: E. c9q3: B.1 c9q4: lab.images-B.1 c9q5: E.1 c9times: 99 9 12 38 20 ...c10q1: hx-pe.rectal-pe.gyn-pe.stomach-pe.heart-pe.chest-lab.test-lab.images-A.1 c10q2: C.1 c10q3: D.1 c10q4: C.1 c10q5: B.1 c10times: 461 46 15 6 4 ...c11q1: hx-pe.eye-pe.neuro-pe.head-pe.extrem-pe.skin-pe.stomach-lab.test-D.1 c11q2: A. c11q3: D.1 c11q4: D.1 c11q5: A.1 c11times: 13 40 10 14 18 ...c12q1: hx-pe.neuro-pe.general-pe.skin-pe.stomach-pe.heart-pe.heart-pe.chest-lab.test-lab.images-C.1 c12q2: lab.test-lab.images-E.1 c12q3: C.1 c12q4: A.1 c12q5: E.1 c12times: 8 52 28 10 8 ...c13q1: hx-pe.eye-pe.ear-pe.neuro-pe.skin-pe.stomach-pe.heart-pe.chest-lab.test-D.1 c13q2: E.1 c13q3: C.1 c13q4: E.1 c13q5: B.1 c13times: 9 6 16 10 19 ...c14q1: hx-pe.neuro-pe.skin-pe.eye-pe.neuro-pe.ear-pe.neuro-pe.stomach-pe.back-pe.heart-lab.test-lab.images-D.1 c14q2: A.1 c14q3: D.1 c14q4: A.1 c14q5: B.1 c14times: 9 22 11 9 12 ...c15q1: pe.pulseO-pe.neuro-pe.skin-pe.ear-pe.skin-pe.pulseO-pe.stomach-pe.chest-pe.heart-lab.test- c15q2: hx-E.1 c15q3: C.1 c15q4: lab.test-E.1 c15q5: B.1 c15times: 13 91 13 51 7 ...c16q1: hx-pe.skin-pe.neuro-pe.gen-pe.stomach-pe.heart-lab.test-lab.images-pe.gen-C.1 c16q2: D.1 c16q3: E.1 c16q4: A.1 c16q5: hx-A.1 c16times: 12 53 11 5 70 ...c17q1: hx-pe.pulseO-pe.general-pe.neuro-pe.eye-pe.ear-pe.eye-pe.mouth-pe.skin-pe.stomach-pe.chest-pe.heart-lab.test-lab.images-C.1 c17q2: D.1 c17q3: C.1 c17q4: lab.images-lab.test-B.1 c17q5: C.1 c17times: 443 27 13 53 8 ...c18q1: hx-pe.hairline-pe.reflexes-pe.arms-pe.eye-pe.mouth-pe.legs-pe.feet-pe.stomach-lab.test-lab.images-D. c18q2: B. c18q3: B. c18q4: D. c18q5: C.1 c18times: 40 11 24 38 27 ...c19q1: hx-pe.mouth-pe.ear-pe.general-pe.chest-pe.heart-pe.stomach-lab.test-lab.images-B.1 c19q2: E.1 c19q3: E. c19q4: lab.test-E. c19q5: D.1 c19times: 13 30 23 42 11 ...c20q1: hx-pe.ear-pe.skin-pe.heart-pe.stomach-lab.test-E.1 c20q2: A.1 c20q3: A.1 c20q4: E.1 c20q5: B.1 c20times: 6 5 17 9 6 ...