

REMOTE EXPERIMENTATION OVER THE INTERNET

By

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ABSTRACT

This thesis is focused primarily on the interactive, on-line operation of remote education laboratory equipment, utilizing the Internet and the World Wide Web. The idea is to develop a remote experimentation system, which will allow efficient use of laboratory equipment for students in a distance-learning environment. The approach is based on newly developed software packages and commercial measurement equipment.

As an example, a remote experiment on electrical device characterization is considered and an actual scenario is described where students can measure the current-voltage characteristics of a diode by accessing the experiment from a remote location.

The primary idea of this distance education project is that of using the computer to provide a more active learning environment, one that demands the involvement of the learner, and that is "self-pacing" in terms of the speed at which material is received and responses made.

The goal is to create software and instructional styles and activities that will enable students and teachers dispersed in space or time to form an active, supportive, and effective learning community.

1

INTRODUCTION AND HISTORICAL REVIEW

Distance interactive learning is an important emerging educational trend. The Internet is an ideal medium for remote instruction purposes. Its ubiquity and protocol standards make data communication and front-end graphical user interfaces (GUIs) easy to implement. The use of the Internet can be greatly enhanced by adding an experimental component, i.e. running experiments remotely over the Internet.⁷

Remote lab courses can be offered to students on a global scale, removing a major obstacle for establishing a boundless and complete remote education curriculum. As an added benefit, this technology offers the students the opportunity to work with sophisticated equipment, of the kind they are only likely to find in an industrial setting, and which may be too expensive for most schools or educational organizations to purchase.

From its inception, the Web was recognized as a low-cost, flexible, and platform independent means for information exchange. In its infancy, Web-based education relied on the distribution of static pages. Unfortunately, in this delivery mode, the only advantages the Web offered over its Internet predecessors, e.g., news groups and gopher servers, were ease of use and the ability to embed graphical content. The lack of interactivity of early Web-based distance education projects presented a significant hindrance to asynchronous learning.

⁷ Shen, Hong; Xu, Zheng; Dalager, B.; Kristiansen, V.; Shur, Michael S.; Fjeldly, Tor A.; Strom, O.; Lu, Jian-Qiang; and Ytterdal, T. *Conducting Laboratory Experiments Over The Internet*. IEEE Transactions On Education, August 1999.

Technological restrictions locked distance learning into a non-interactive structure. In an educational context, World Wide Web clients were considered to be of limited value because they put learners in the role of information absorbers. Early attempts to raise the level of interactivity usually led to combined Web courseware approaches. The well-known limitations of these linearly structured teaching methods drove many distance education programs to evolve from repositories of static information into vehicles for interactive long-distance training as the technology became available.

Indeed, the amazing increase in browser functionality has drawn many educators to the Web in recent years. Several tightly integrated educational environments have resulted from research and development in this area. This provides means for the instructor to rapidly develop and deploy an on-line curriculum.

The remote learning environment does not intend to replace the conventional classroom; instead, it is designed to enhance out-of-classroom learning.

1.1. Distance Teaching

Distance teaching quite simply means that the students and teacher are at a distance from one another, with little opportunity for face-to-face contact.⁶ They are, however, able to have joint educational activities through the use of various instructional media geared to facilitate learning on the part of the students. The bulk of this learning arises from self-study, at times and places convenient to the students. Distance teaching

⁶ Lovis, F. *Remote Education And Informatics: Teleteaching*. Elsevier Science Publishers B.V. (North Holland) IFIP, 1988.

thus involves the communication of knowledge, attitudes and skills to learners in such ways as to enable them to acquire and extend them into the conduct of their everyday lives. Since communicating the above-mentioned items is the prime objective, this communication must be as efficient and effective as possible within the constraints of existing resources. In general, the criteria for determining the efficiency and effectiveness of distance teaching involves analyzing the extent to which learners have achieved the learning objectives set by the curriculum or by themselves.

1.2. Decentralized Education

For many years we have relied upon a centralized approach to education and training based upon scheduled classes and schools. This approach no longer fits our highly mobile society or the continuous learning needs of students. A great problem in both education and training is that instructional activities are poorly timed. A student's interest in, or need to know about a subject often does not coincide with when that subject is taught. Even when instruction is provided in a timely fashion, there is still a problem of exactly meeting a student's needs. This is the limitation of any group based (i.e. classroom) teaching.⁵

In the remote learning environment, one obvious advantage is that the student need not adhere to a rigid schedule of class meetings. A not-so-obvious difference is that the computer-mediated environment can more easily support a collaborative learning process than can the traditional classroom; a process in which the student and the instructor are actively involved in creating and carrying out learning activities, together.

⁵ Kearsley, Greg. *Training For Tomorrow: Distributed Learning Through Computer And Communications Technology*. Addison-Wesley Publishing Company, 1985.

The relative effectiveness of a distance learning program is contingent, not only on hardware and software capabilities but also on the teacher conducting the course in a manner that fits the characteristics of the medium, the nature of the course materials and the characteristics of the students. Learning outcomes in the remote learning environment depend on whether or not teachers and students take advantage of its potential to support an active learning process that incorporates extensive interaction among students and between instructor and students. A successful outcome also requires adequate access to the necessary equipment, like PCs and modems.

1.2.1. Advantages

❖ Location

Students may take any course from any instructor from any institution in the world, which is offering courses in this mode. Thus, they are not limited to courses and degree programs offered in their geographical location.

❖ Flexible Time

Students may participate at any time of the day or night that they have the time and the inclination. Opportunities for feedback from the instructor and interaction with other students are not limited to a few fixed times per week.

❖ No Travel

Students for whom travel is difficult may work from the relative comfort and convenience of their homes. This might include the handicapped, or those who must be at home as much as possible to care for children or other dependents.

Alternatively, they can work while traveling, using a portable computer.

❖ Shared Work Space

The technology makes it easy to exchange information that is difficult to share or disseminate in the traditional classroom. For example, a computer program, as well as the output from a run, may be passed back and forth among students or between student and instructor, for discussion of problems or possible bugs. Some students may be given the privilege of looking at the drafts of completed assignments of other students, in order to comment, compare, or offer constructive criticism.

❖ Participation Opportunity

This program also allows all students an equal opportunity to ask questions and make comments, even if they have difficulty in putting their ideas into words quickly. They may take as long as they need to formulate their questions and contributions.³

1.2.2. Limitations

However it must also be recognized that, at least when used as the sole means of educational delivery, access may be limited in the following ways:

❖ Limited Course Offerings

³ Hiltz, Starr Roxanne. *The Virtual Classroom: Learning Without Limits Via Computer Networks*. Ablex Publishing Corporation, 1994.

Currently only a few institutions offer a few courses online. If a student wishes to complete an entire degree program online, the choice of courses is severely limited at present.

❖ Equipment Requirements

Students who do not have access to a personal computer and modem at home or at school will be disadvantaged relative to those who have the equipment that makes access convenient. This is likely to be related to socioeconomic status, since the poor are not likely to own computers, modems, etc., or have access to an institution which can provide them with such equipment.

❖ Delayed Feedback

In the face-to-face laboratory, as soon as a question is asked, the answer may be received. In this asynchronous medium, it may be hours or as long as a day until an answer is received. Moreover the teacher might be more likely not to answer at all, or to send a “group answer” to several related messages, which does not deal adequately with each one.

❖ Asynchronous Communication

Immediate feedback is possible with this medium, if the participants are online at the same time. Students working together may arrange to be online at the same time, so that they can pass drafts back and forth and engage in near-instantaneous exchanges of remarks. Students may also work side by side in a laboratory setting, talking about and pointing to things on the screen. However these are the exception. Most of the time, communication will be asynchronous, with answers to questions delayed.

❖ Textual Skills

Students with poor reading and writing skills may have their effective access lessened, since the communication in currently implemented systems is based on writing (typing) and reading.

❖ Technical Skills

Lack of skill using a computer, and software bugs or hardware “crashes”, might severely hamper timely exchange of communication.

The distance education program offers students a Web based, asynchronous learning environment that complements the traditional means of classroom instruction. By now, the benefits of Web-assisted teaching techniques are recognized by many. On-line teaching provides students with a learning environment free from conventional time, physical, and geographical constraints. Therefore, on-line teaching approaches are highly scalable and cost effective. In addition, the demand for on-line education is on the rise: continued education programs are becoming an integral part of many working environments and “formal education is becoming a lifelong endeavor”.

Finally, beyond their utilitarian value, asynchronous learning systems have also been found to be resoundingly attractive to students and educators who implement them. In the remote learning environment, it has been found that students and faculty benefit from interactions both among themselves and with the course material. Remote labs have been shown to effectively enhance learning in a variety of disciplines and are especially beneficial when teaching electronics principles.

The introduction of computers into the classroom not only permits the visualization of physical phenomena, but also exposes students to modern computational techniques that are vital in many industrial analysis and design environments.

2

EFFECTIVE DISTANCE EDUCATION

Ideally, an effective distance teaching system should ensure that the students find the learning experience stimulating, interesting, enjoyable and relevant to their aspirations and lifestyles. Thus the effectiveness of distance education depends to a large extent on the quality of the instructional media and delivery systems.

2.1. Media Selection

The selection and development of instructional media appropriate to the conditions of individual societies is thus an important problem.⁶ Factors to be considered in media selection include the following:

❖ Availability

It is essential that the chosen instructional media and delivery systems be technologically practicable; that is, the technology to be used in the individual societies must have been adequately developed, and there must be sufficient manpower to make continued use of the technology.

❖ Accessibility

The instructional media and the delivery systems to be used must be accessible to both the distance teaching institution and the learners. For example, if television is chosen as an instructional medium, not only must there be appropriate and

⁶ Lovis, F. *Remote Education And Informatics: Teleteaching*. Elsevier Science Publishers B.V. (North Holland) IFIP, 1988.

adequate air time, but also the students must have TV sets capable of picking up the programs.

❖ Acceptability

The instructional media must be accepted both by the teachers and the students. This concerns the aptitudes and attitudes of both groups with respect to certain types of media. If the teachers or students are not skilled in the use of a particular medium, it is not likely to be very effective.

❖ Validity

The instructional media must be appropriate for achieving the objectives of the learning materials. Care must be taken to choose media which are suitable for the content or subject matter one wishes to convey.

❖ Economics

The instructional media must not be over expensive. This will involve considerations of economies of scale and cost effectiveness.

Other than these factors, learner characteristics, learning outcomes, events of instruction and physical attributes of media are all interdependent, but in themselves not related to specific instructional systems. However, an analysis of these factors will sometimes lead to strong media choices which entail practical aspects, which in turn are not feasible in distance education. In such cases, either another instructional situation should be chosen, or amends should be made with relation to the target audience or the learning objectives.

3

IMPLEMENTING DISTANCE LEARNING

Distance learning can be considered as covering the various forms of study at all levels which are not under the continuous, immediate supervision of tutors present with their students in lecture rooms or on the same premises, but which, nevertheless, benefit from the planning, guidance and tuition of a tutorial organization.

3.1. Distance Learning Centers

Distance Learning centers should provide a cost-effective way to set up a database of remote labs and information in general for use by university administration, staff, students, companies, and remote organizations cooperating with the university or educational institution.⁶

The following desired features have been identified for the implementation of Distance Learning centers:

- ❖ The software to run a Distance Learning center should be compatible on a variety of machines and be able to be executed on equipment also used for other purposes. The decision to acquire a dedicated central computer for the Distance Learning center can be postponed until a certain volume of activity is reached, so that Distance Learning centers can be easily upgraded.

⁶ Lovis, F. *Remote Education And Informatics: Teleteaching*. Elsevier Science Publishers B.V. (North Holland) IFIP, 1988.

- ❖ A large database of executable experiments and some basic general information must be provided on a computer of the network, which will serve as the host PC.
- ❖ The retrieval of experiments and of information must be straightforward and clearly explained to students by walking them through the process step-by-step. One must be able to use the system without prior knowledge of any operating system intricacies.
- ❖ Access to the Distance Learning center should be possible through existing LANs and a switched telephone network. The system must also permit the use of slow speed communication lines. This is certainly important to allow wide access and to avoid unacceptable waiting times.
- ❖ A Distance Learning center should provide general information and tools supporting the teaching process, e.g., self tests for students, counseling for students, and most importantly a large library of high quality tutorials on individual experiments and labs for reference, accessible by authorized users on and off campus.
- ❖ A Distance Learning center should provide the tools for tutorial maintenance and distribution, as well as a communication component for permitting feedback on the quality of the experiments, allowing students to ask questions or concerns via email, etc.

Distance Learning Centers will usually provide an “induction session” at which a group of students are exposed to the remote education environment, and are shown exactly how to access

the system and work at a terminal. However, students will often have no previous experience of using the system and there will be no one immediately available to answer their questions should difficulties arise. It is essential that students plan their activities carefully before going to the distance-learning center so that the booked sessions are utilized fully.

A Student At A Distance Learning Center



Figure 3.1

4

THE INSTRUCTOR'S PERSPECTIVE

We have seen that the remote experimentation project is a teaching and learning environment located within a computer-mediated communication system. As a teaching environment, it provides a set of tools, strengths and limitations that are available to an instructor for delivering course materials and structuring learning experiences. Its characteristics are merely potentials, just as the empty classroom with its chalkboards and desks awaits the efforts and creativity of the instructor and the students to make it "come alive".

This section looks at the remote experimentation project from the teacher's point of view. Its purpose is to present the lessons learned by the faculty members who have participated in the project, particularly in terms of guidelines or generalizations that may be of use to future instructors who are considering using this kind of computer-mediated communication as a mode of educational delivery. It is directed primarily toward the prospective educator.

However, understanding the pedagogical guidelines and instructional designs and processes that apply to remote experimentation is also of fundamental importance for those whose interests in online learning lie elsewhere. Prospective students in online courses can gain insight into what their experiences are likely to be by seeing how the teaching process differs between remote experimentation and the traditional classroom.

Just as there is no single recipe for successful teaching in the traditional classroom, there are diverse techniques which can be successful in the computer-mediated environment. Whatever strategy is initially chosen will have to be modified on the basis of observations about the level of ability and motivation of the students; this is true in any medium. However, there are some fundamental differences in teaching between the remote education situation and the traditional classroom, stemming from the differences between the communication channels.

4.1. Basic Principles For Successful Teaching

There are four basic principles to keep in mind for successful teaching in a remote learning environment³, dealing with media richness, suitable courseware, timely responsiveness, and interaction:

❖ Media Richness

In the traditional classroom, a pleasing voice, occasional jokes, dramatic gestures, and interspersed questions can help to enliven a long lecture. In computer-mediated communication, there is only the screen and printed pages. Even if the workstation supports color graphics and sound, long segments of lecture-type materials are boring. To maintain interest, the instructor should use written language in a skillful way (using humor is a good idea) and orchestrate active participation by the students, and stimulate collaborative assignments that involve both social and task-oriented activities.

❖ Suitable Courseware

³ Hiltz, Starr Roxanne. *The Virtual Classroom: Learning Without Limits Via Computer Networks*. Ablex Publishing Corporation, 1994.

The teaching material developed by the instructor for the remote education course must incorporate the following features:

1. “Hands on” practical work involving appropriate equipment.
2. Case studies which show ideas in an industrial context.
3. Regular self-assessment questions posed to the student throughout the course text.
4. Video material, showing working equipment or processes, or the utilization of dynamic graphics to illustrate complex interactions.

Of course, it is not possible for the instructor to anticipate with any precision the student reactions to the materials that are developed. Numerous value judgments and some creative imagination are needed in sequencing the materials within a lesson and in branching the student to different difficulty levels.

❖ Timely responsiveness

Unlike the face-to-face medium, students will not receive an immediate response to their questions and comments. This can be very frustrating, especially if they are "stuck" in the middle of a problem or other assignment. However, whereas they may have only a limited opportunity to ask questions during a few set hours a week for a traditional class, they can participate and receive feedback on a daily basis via the distance-learning environment. But this depends on the instructor, who needs to sign on everyday except for occasional announced exceptions

to this policy, and respond to all waiting material. This is what is meant by the "perpetual professor" – that teaching is continuous, like parenthood, rather than being confined to a few hours during the week.

❖ Interaction

Probably the greatest determinant of the extent to which students feel that the online mode of delivery is better or worse than traditional modes is the amount and quality of interaction between the instructor and the students, and/or among the students. This is not easy, but if you can cajole or coerce the students into this collaborative approach to learning, they will share ideas with each other in a way that is seldom or never seen in a traditional classroom. Herein lies both the key and the challenge for being an effective teacher in the remote learning environment.

4.2. Assuring Access To Students

The following section provides a brief overview of some techniques that can be used to improve the probability of providing a valuable learning experience for students in online courses:

If students are to participate effectively in a distance education program, they must have adequate access to the system, feel comfortable with the medium and with each other, and know what is expected of them. The instructor must be competent using the system and have a course design worked out ahead of time which is appropriate to the medium and the capabilities of the specific system.

Instructors should have access to a computer, modem and printer from their home as well as from their offices. In preparing for, and offering an online course they will be spending several hundred hours online.

Ideally each student would also have access to online course material through a computer and modem at home, as well as equipment at school. In the ideal setup the communication software and access procedure would all be the same, so that a single set of instructions for connecting to and using the computer-mediated communication system would suffice. One cannot expect each individual student to master several kinds of hardware and communications software.

To help remote students with their own computers, the instructor must develop a set of printed materials, which shows how to use the most widespread combinations of hardware and software they have. Instructions for reaching the system through packet-switched networks (including inter-university links such as Telnet) or local area networks, as well as direct dial, must also be provided. Recommending a single communications software package, for the students to acquire, and giving instructions for how to correctly set the communications parameters for these packages is absolutely essential.

The instructor must decide how he/she is going to introduce the students to the system and ease them online.³ Some of the options may be sending printed instruction or tutorials, providing a videotape, or having a face-to-face meeting in a computer laboratory. If the students are computer novices, they may need an introduction to PCs first as a separate laboratory.

³ Hiltz, Starr Roxanne. *The Virtual Classroom: Learning Without Limits Via Computer Networks*. Ablex Publishing Corporation, 1994.

An initial face-to-face meeting where students meet the instructor and other students, and learn the basics of using the system is a good idea if geographical dispersion makes this practical. If “hands on” training in system use, rather than just a demonstration, is preferred, there should be not more than two students per terminal, and one assistant to help every four to six learners.

4.3. Initial Activities On Getting Started

An individually addressed message waiting for each class member when they sign on is a neat way of welcoming them to the distance education course. Students may also be asked to send a message back to the instructor describing any impressions or difficulties so far. If the system being used does not automatically store a record of when messages are received, it is a good idea for the instructor to keep his/her own list of the progress of the beginners in finding their electronic way to the class.

5

THE REMOTE EDUCATION ENVIRONMENT

In this thesis, the attempt was to specifically design a remote education environment for learners who do not have access to a classroom studio environment for their course labs where they can execute experiments in an instructor's physical presence. Thus we will have a distance-learning center for remote students, complete with experimental equipment and computers with network access, where learners can run remote experiments or labs which are actually physically hardwired at the host location.

Each computer terminal at the distance-learning center will also have a video camera and speakers which will allow the student to utilize the video conferencing link which is setup to enable two-way communication between the host and remote location. We will also have an on-campus facility at the host location with identical equipment that can be used by instructors to interact with off-campus students via video conferencing. We have not fully implemented anything, but have the basic ingredients of a workable system.

5.1. Distance Delivery Mode

To implement the remote experimentation course we utilized a software called HPVEE to control experiments and collect data

from the electronic measuring instruments.² By extending the use of such visual programming software to all aspects of each experiment and standardizing the experimental apparatus, it becomes possible to run the labs remotely. If the remote operation is to be done over the web, it is necessary to add one more piece of software, something like pcAnywhere to access the routines local to the apparatus over the web.

We have successfully added the experimental control using HPVEE and tested the remote web access. A set of instruments like the one in the studio classroom has been acquired for the remote site and used to develop selected experiments in a distance delivery mode. These instruments have been set up with the necessary computer control, so that the technological feasibility of the proposed approach can be demonstrated. This will permit remote students to take a lab course using one of two options:

- ❖ They have a complete set of apparatus on site and only need assistance and directions from the instructor.
- ❖ They are supposed to connect to the campus lab and perform experiments by either using a setup prepared in advance or by running virtual experiments. The implementation of this approach will also require more extensive notes than are now in use for the on-campus course, since there is no instructor at the distant site.

While the primary goal of this work has been to develop a practical method for providing a laboratory experience to remote students, we have invested equal thought in developing ideas for increasing the quality of this experience while also

² Helsel, Robert. *Visual Programming With HPVEE*. Hewlett Packard Professional Books, Prentice Hall PTR, 1997.

addressing costs. It is our hope that the distant student's experience will be as rich as that of their on-campus peers, while not requiring large investments in staffing and equipment, and only involving the most simplistic distance delivery systems feasible.¹

Some of the advantages of the present approach include:

- ❖ Remote operation of experiments using a simple computer interface such as pcAnywhere.
- ❖ Virtual experiments that look and feel like real experiments so that we have a backup in case of equipment failure or to provide a type of experimental activity at remote sites without equipment.
- ❖ Video display of on-campus experiments so the student and instructor can be looking at the same apparatus as they address the student's questions.
- ❖ A set of on-campus experiments selectable by off-campus students who do not have access to an equipment set.
- ❖ Video connections so that we can see the experiment the student is working on and thus, provide more help.

Thus the standard experiment station at a distance-learning center for the remote lab course consists of a computer, a 60MHz Oscilloscope, two triple-output DC power supplies, a digital multimeter, and a 15MHz function generator. Software packages on the computers include Netscape, Matlab, Maple, OrCAD Capture and PSpice, Excel, HP Benchlink Suite, HPVEE and XWin32.

¹ Connor, Kenneth A. and Podowski, Michael Z. *Distance Delivery Of Undergraduate Laboratories*. December 1999. <http://hibp7.ecse.rpi.edu/~connor/DistanceLab.PDF>

5.2. Step-By-Step Instructions For The Student

At a distance-learning center, the student first needs to log in to the system by keying in his/her assigned user-id and password at the computer terminal.

Once authenticated by the system, the next step for the user is to start up the video conferencing link by double-clicking the “Conference Manager” icon on the screen. The student must now dial in to the host by entering the host PC’s IP address and pressing the “Enter” key. Detailed instructions must be provided to students about how to adjust audio/video settings on the video conferencing utility and also, information on additional features like “Chat” and the “Whiteboard” which can be used for sharing information, should be provided.

The next step is to activate the pcAnywhere Express client and enter the host’s IP address. After the connection is established with the host, the student actually has limited control over the host PC’s desktop. It is important to mention at this time that student accounts should be setup in such a way that only restricted access is allowed to the host machine. This is done in an attempt to enforce security considerations so that students don’t go hacking into the host machine.

The student then opens up the desired lab and executes it by following the simple instructions that appear on the screen. In our particular implementation of the distance-learning environment, the labs were written using HPVEE which is a powerful visual programming language. The student is not required to have any prior knowledge of HPVEE, as a user-friendly interface is provided through which the student actually executes the lab from the remote location. While the lab is being executed, the student may observe via the video

window of the video conferencing link, the way the readings on the front panel of the measuring instruments are changing instantaneously.

Also, assistance may be obtained from the course instructor or a teaching assistant present at the host location via the real-time video conferencing link, which helps to better convey to the students the ideas and concepts that are being explained in the lab courseware, because they can see the way a particular lab is set up in hardware and also clarify any doubts as and when they have any.

5.3. The Actual Setup

5.3.1. The Host Location

The hardware components of the system at the host location include:

- ❖ The Host PC
- ❖ Electronic Measuring Instruments
 - HP 54603B 2 Channel 60MHz Oscilloscope
 - HP 33210A 15MHz Function/Arbitrary Waveform Generator
 - HP 34401A 6-1/2 Digit Multimeter
 - HP E3630A and HP E3631A Power Supplies
- ❖ Circuit being studied
- ❖ Intel ProShare Video Conferencing System
 - Video Camera
 - Microphone
 - Audio Speakers
 - A/V Card installed in the PC

The software components involved are:

- ❖ HPVEE
- ❖ Symantec pcAnywhere
- ❖ Video Conferencing software

On the host side of the implementation, the lab or experiment to be performed is loaded on the PC in the form of an HPVEE program, and the circuit being studied is hooked up to the electronic instruments accordingly. The electronic measuring instruments are daisy chained to the PC via the HPIB (Hewlett Packard Interface Bus) port.

A video camera is directed toward the circuit setup so that students at a remote location (also with a videoconferencing setup on their end) may “see” the physical connections involved in the circuit and be able to understand the way electronic measurements are being made in the particular experiment.

Hardware Setup At The Host Location



Figure 5.1

5.3.2. The Remote Location

The hardware components at the remote location are:

- ❖ The Remote PC
- ❖ Intel ProShare Video Conferencing System

- Video Camera
- Microphone
- Audio Speakers
- A/V Card installed in the PC

Software Components include:

- ❖ pcAnywhere Express
- ❖ Video Conferencing software

The student at the remote location uses the pcAnywhere Express client on his/her PC to access the host computer. pcAnywhere Express is a software that gives remote students control of the host machine's desktop and then allows them to work as if they were working at the host PC itself. The host PC must be running as a pcAnywhere host at the time.

For security reasons, there must be some form of authentication built into the system so that first of all, only students that belong to those particular institutions that have signed up for the distance education program may access the labs and education software on the host PC. Also care must be taken that once students have access to the host PC they should not be allowed to tamper with control settings or other administrative aspects of the host PC.

pcAnywhere Express Client

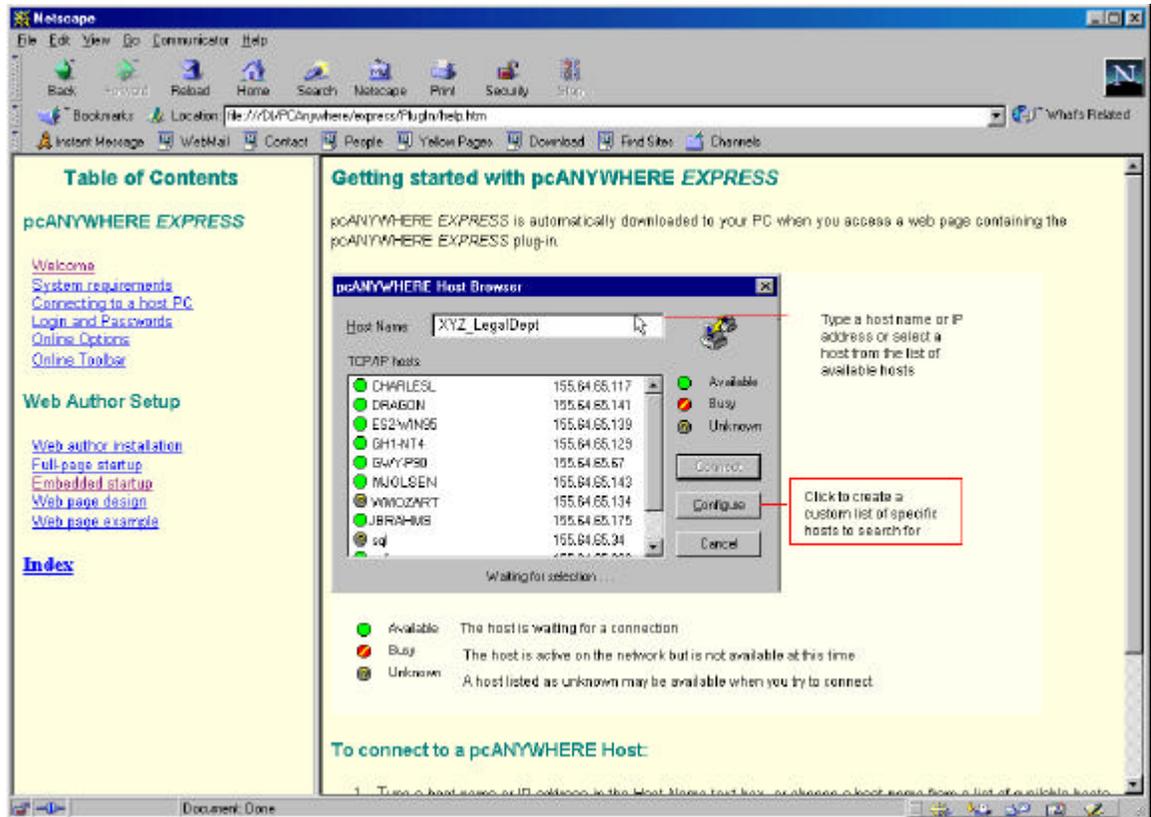


Figure 5.2

Hardware Setup At A Remote Location



Figure 5.3

6

PCANYWHERE

pcAnywhere as the name suggests, is software used to remotely control a PC from anywhere via a modem, or the Internet. pcAnywhere supports a wide range of connection methods on the Internet and other networks, including TCP/IP connections and standard modems.

6.1. pcAnywhere Host Browser

This is what the student actually sees when he/she first logs on to the system and starts up the pcAnywhere Express client. At this point the student is prompted to enter the IP address of the host PC with which the connection is trying to be established.

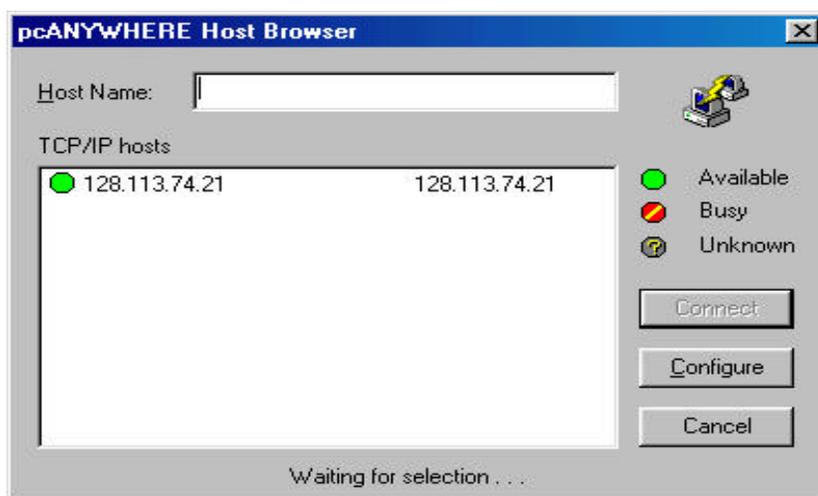


Figure 6.1

After a connection is made, the student gains access to the host computer, and opens up the desired HPVVEE program depending on which lab is to be executed. The student is then

guided through the HPVVEE program and given step-by-step instructions about how to execute the desired lab, and monitor the results.

For more detailed information on pcAnywhere please visit Symantec's website at:

<http://www.symantec.com/pcanywhere/index.html>

Other remote control software options include:

- ❖ Control*IT* (formerly called Remotely Possible)
- ❖ PC-Duo

Additional information may be obtained at:

<http://www.cai.com/products/controlit.htm> <http://www.vector-networks.com/pcduo/index.htm>

7

VIDEOCONFERENCING

The video conferencing utility is setup to enable two-way communication between the student at a remote location and the host computer. This would not only serve the purpose of aiding visual perception of the experimental setup through video, but also add in a new dimension of user interactivity by the possible incorporation of "live" help sessions that could be conducted with the course instructor or a teaching assistant, by utilizing the audio and video resources of the video conferencing system. Thus, students at a remote location could receive immediate assistance with their difficulties, depending on the availability of the instructor or a TA at any given time.

The specific software that was used in this project was the Intel Business Video Conferencing with ProShare Technology v.4.01. This particular software was chosen even though the video resolution on the screen is not very good, but the advantage is that it is not demanding on connectivity.

We have chosen to use inexpensive, affordable software that any school or educational organization might be willing to purchase.

For additional information on Intel's ProShare Technology please see: <http://www.intel.com/proshare/index.htm> and click on "Desktop System".

7.1. Videoconference Setup

Configuring the Conference Manager appropriately and dialing in to the host PC by keying in its IP address, starts the videoconference.

Once the conference is in progress, the Video Window shows the Local site on the left half of the screen and the Remote site on the right half. The figure below shows the host PC desktop just before the videoconference has been set up. The Local site shows the physical circuit connections for the lab currently being studied.

Host PC Desktop

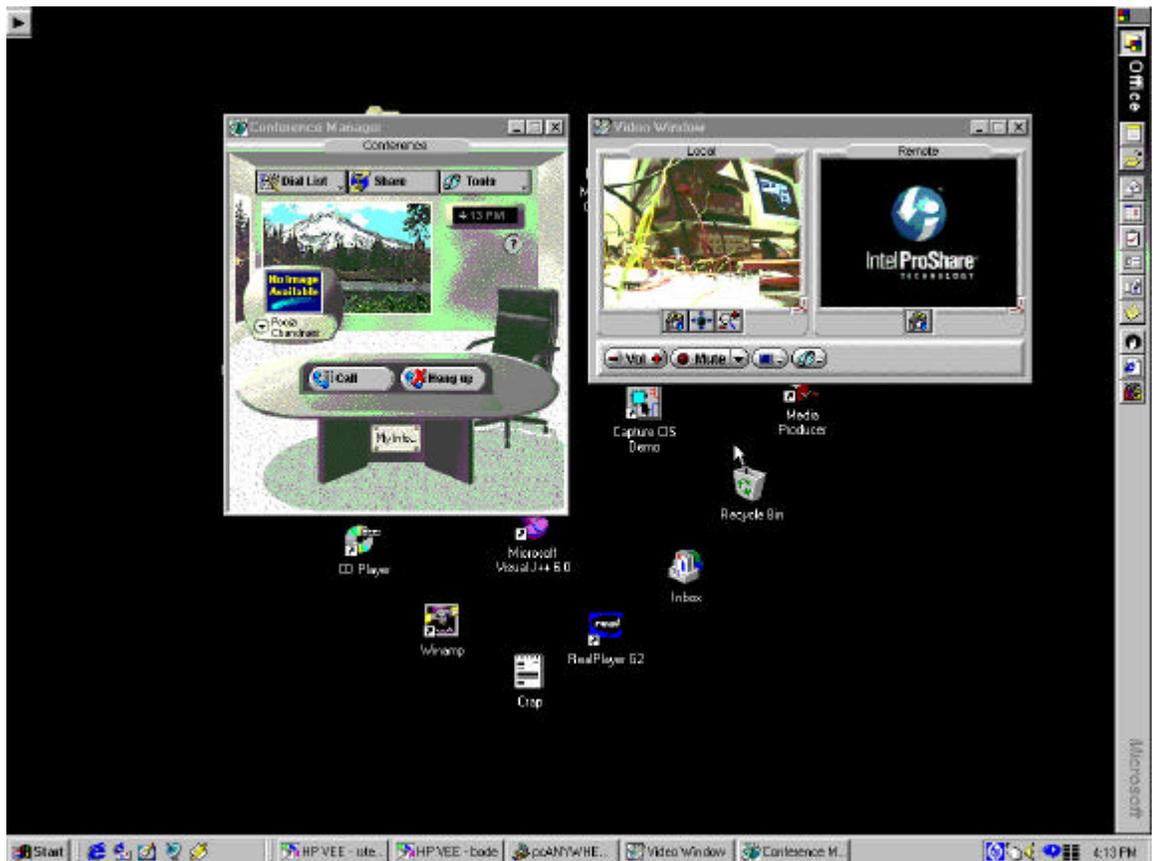


Figure 7.1

As can be seen from Figure 7.1, the audio and video controls that are located just below the video window allow the student to adjust the videoconference settings to his/her individual preference. Volume control is provided as well as the ability to pan the camera in a particular direction or to zoom in and out of the video window.

There is also a chat utility available while the conference is in progress, in case the student wishes to ask an instructor or teaching assistant any difficulties that may arise in the course of the lab, by way of typing them out in textual form. If the course instructor or TA happens to be online, the student will get an immediate response. An electronic whiteboard may also be used if the teacher and student prefer to be more graphic and colorful in their approach.

7.2. Videoconferencing Impact

Much of the research on video conferencing has focused on the idea of the appropriateness of alternative communication modes for different functions.

Media differ in “social presence”: the feeling that a medium is personal, warm and sociable rather than impersonal, cold and unsociable. By adding in the video conferencing feature in the remote learning environment, we have removed the possibility of there being a paucity of nonverbal cues which may have potentially limited information that serves to improve perception of communication partners, to regulate social interaction, and to provide a meaningful context for communication.

In designing the remote learning environment, we desired to identify software structures and teacher behavior or approaches that would support the full range of communication necessary for effective education. This includes structures to organize and regulate student activities as well as processes to encourage the social and emotional interaction necessary in order for students to establish cooperative relationships with their instructor and peers.

8

HPVEE Hewlett Packard Visual Engineering Environment

HPVEE is a visual programming language (also called a graphical programming language) optimized for building test and measurement applications, especially programs with operator interfaces.

8.1. Why HPVEE?

With HPVEE you create programs by connecting icons together using a mouse; as against a textual language where you use keywords following rules of syntax. The resulting HPVEE program resembles a data flow diagram, which is easier to use and understand than traditional lines of code. There is also no laborious edit-compile-link-execute cycle using HPVEE. Time-consuming tasks such as controlling instruments, creating customized data displays, or developing operator interfaces become very easy using HPVEE. This method of test development leads to productivity gains up to five times greater than conventional techniques.

8.2. HPVEE Basics

An HPVEE program consists typically of "objects" interconnected with each other by "lines".

The lines may be:

- Data Lines
- Sequence Lines

Schematic Of An HPVEE Object

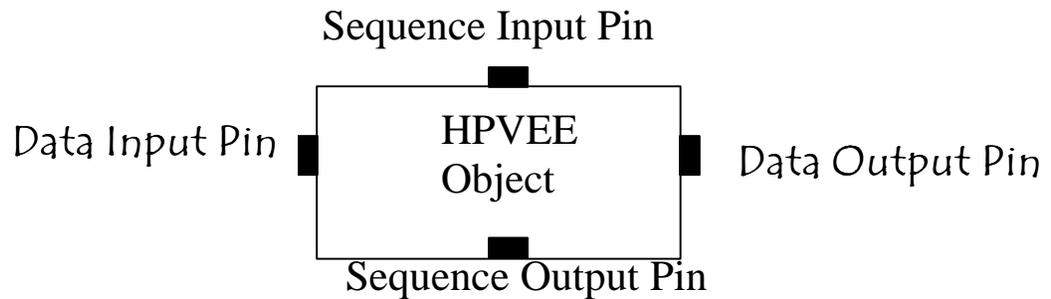


Figure 8.1

The lines connecting HPVEE objects together are attached to the “pins” on the object. The data input and output pins carry data between objects. The sequence pin connections are optional. If connected, they dictate an execution order flowing from the top of the work area to the bottom.

Terminals are simply the open view representation of the data pins. They carry detailed information such as the name of the terminal, the type and value of the data being transmitted.

After the HPVEE program has been created, the student must hit the “Run” button (which looks like a little black triangle) on the toolbar, to execute the program.

To control electronic measuring instruments like the cathode ray oscilloscope, multimeter and function generator that are

used to make measurements on the circuit being studied, HPVee provides a “panel driver” for each instrument that gives you a simple user interface to control the instrument from your computer screen. The panel driver physically looks almost exactly like the front panel of the real instrument. And by correctly connecting the actual circuit, and hooking up the measuring instruments to it, the parameters being measured by the electronic instruments, like current or voltage, are then automatically transmitted to the computer and can be saved as data in a file for further manipulation.

In the sample HPVee program coming up, the I-V characteristic of a diode is to be studied. So the parameters being measured in the circuit are the current flowing through the diode and the voltage drop across it. Since HPVee supports Dynamic Data Exchange, after the data is collected by the HPVee program, it is dynamically sent to a Microsoft Excel worksheet where the Current and Voltage values are presented in two adjacent columns in tabular form, and the corresponding Current vs. Voltage (I-V) curve is also plotted to aid visual perception of the data collected.

Additional information on HPVee can be found at:

www.tm.agilent.com/tmo/pia/HPVee/PIATop/English/

An alternative software that may be used for graphically programming the remote labs is a software called LabVIEW by National Instruments. Please see their web page at <http://www.ni.com/labview/> for more information.

HPVee was chosen in this project because of its ease of use and simplicity.

9

AN ACTUAL EXPERIMENT

I-V Characteristic Of A Diode

Once connected to the host computer, the student starts up the HPVVEE program and chooses which lab to execute. Let us assume the student is trying to execute the experiment called “I-V Characteristic Of A Diode”. He/she is then prompted to enter the conditions under which the experiment is to be performed, like the input voltage range of the function generator, the step size of the variation, etc.

Once these specifics are obtained, the student hits the “Run” button and the experiment starts executing. The input voltage of the function generator is swept through the specified range, thereby varying the voltage drop across the diode, and the multimeter which is connected in series with the diode and load resistance, measures the current flowing in the circuit.

As the values are being read off the measuring instruments, a plot of the current vs. voltage characteristic of the diode is also being drawn in real time almost simultaneously. After the program has finished executing, the student can play with the markers on the HPVVEE plot to read the co-ordinates of different points on it. The slope of the I-V curve can also be computed using the differential markers, thereby giving the dynamic resistance of the diode.

Circuit Diagram To Measure I-V Characteristic Of A Diode

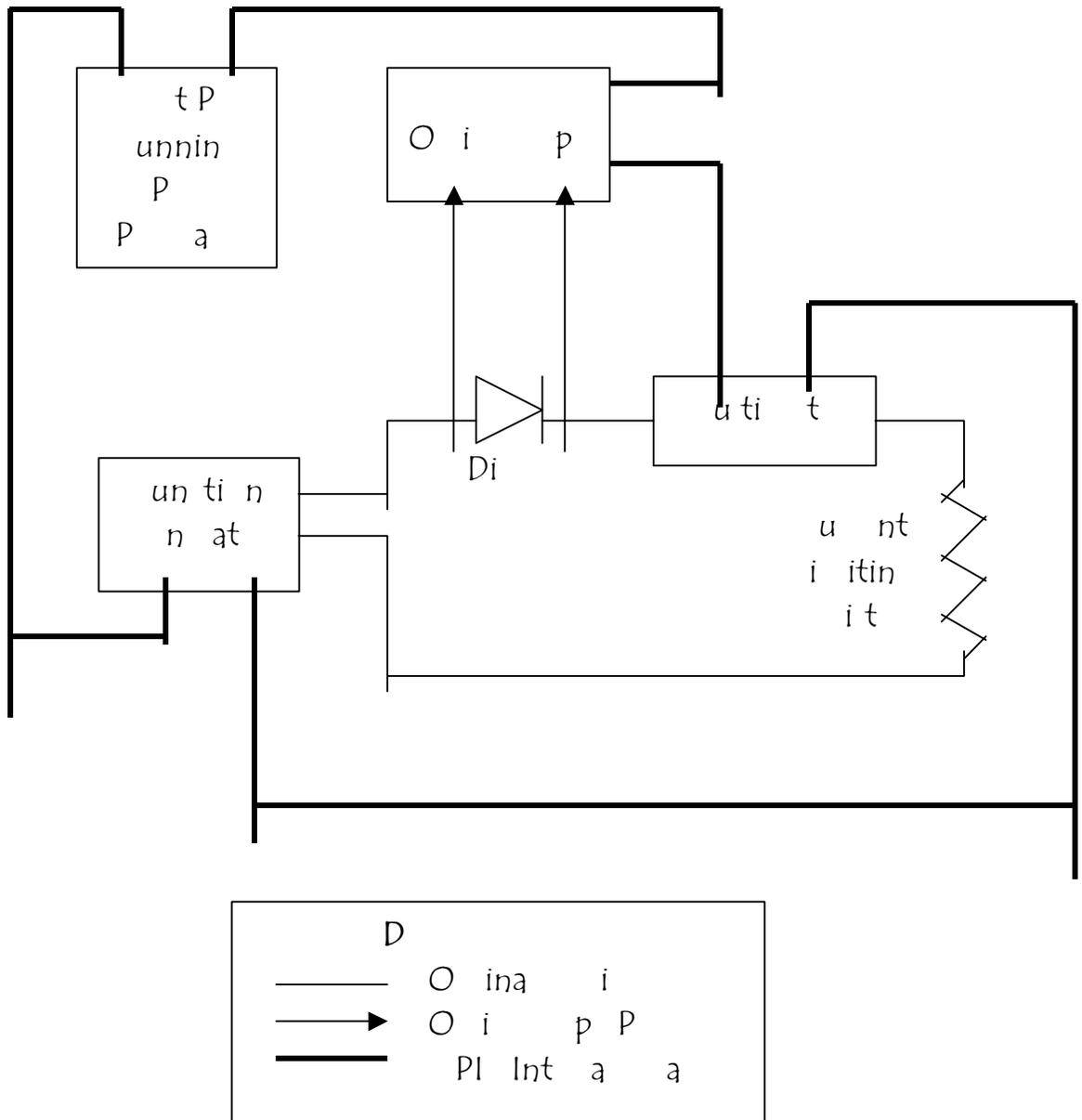


Figure 9.1

HPVEE Program For Plotting The I-V Characteristic Of A Diode (HPVEE Detail View)

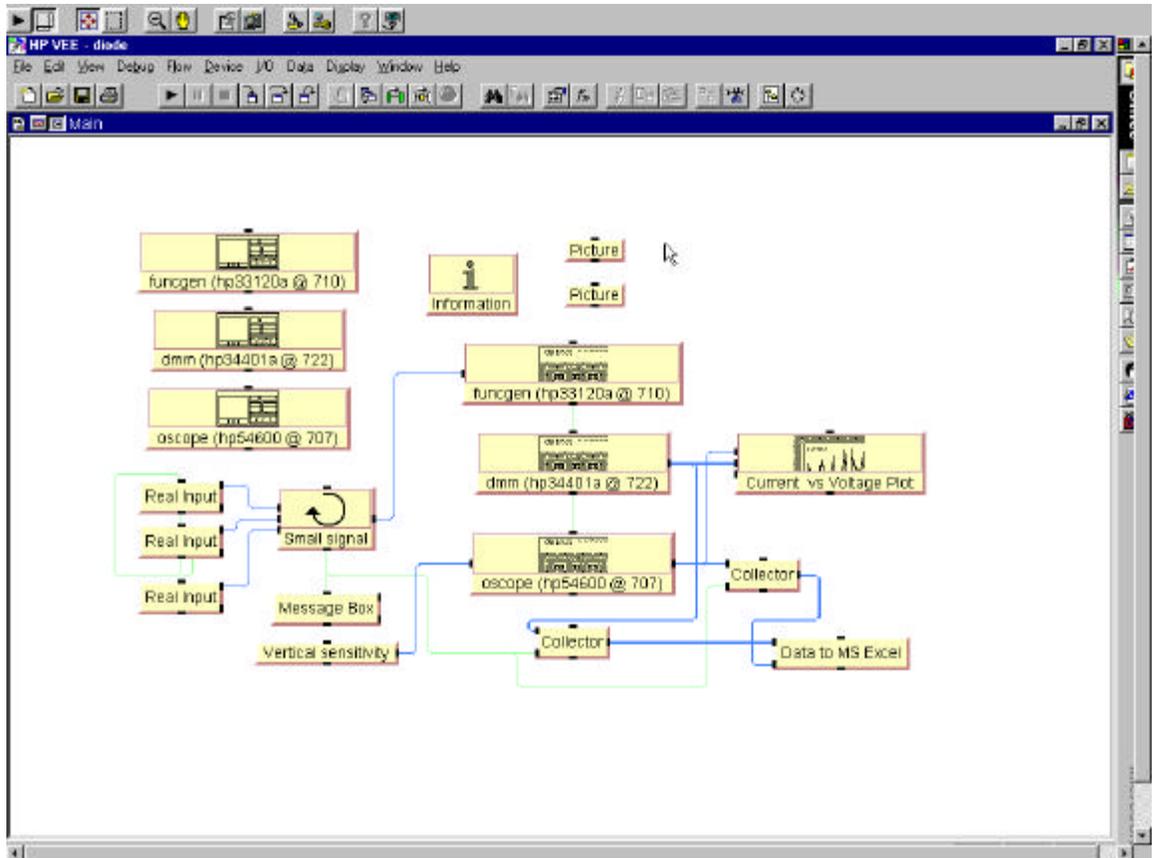


Figure 9.2

Student's View Of The Experiment (HPVEE Panel View)

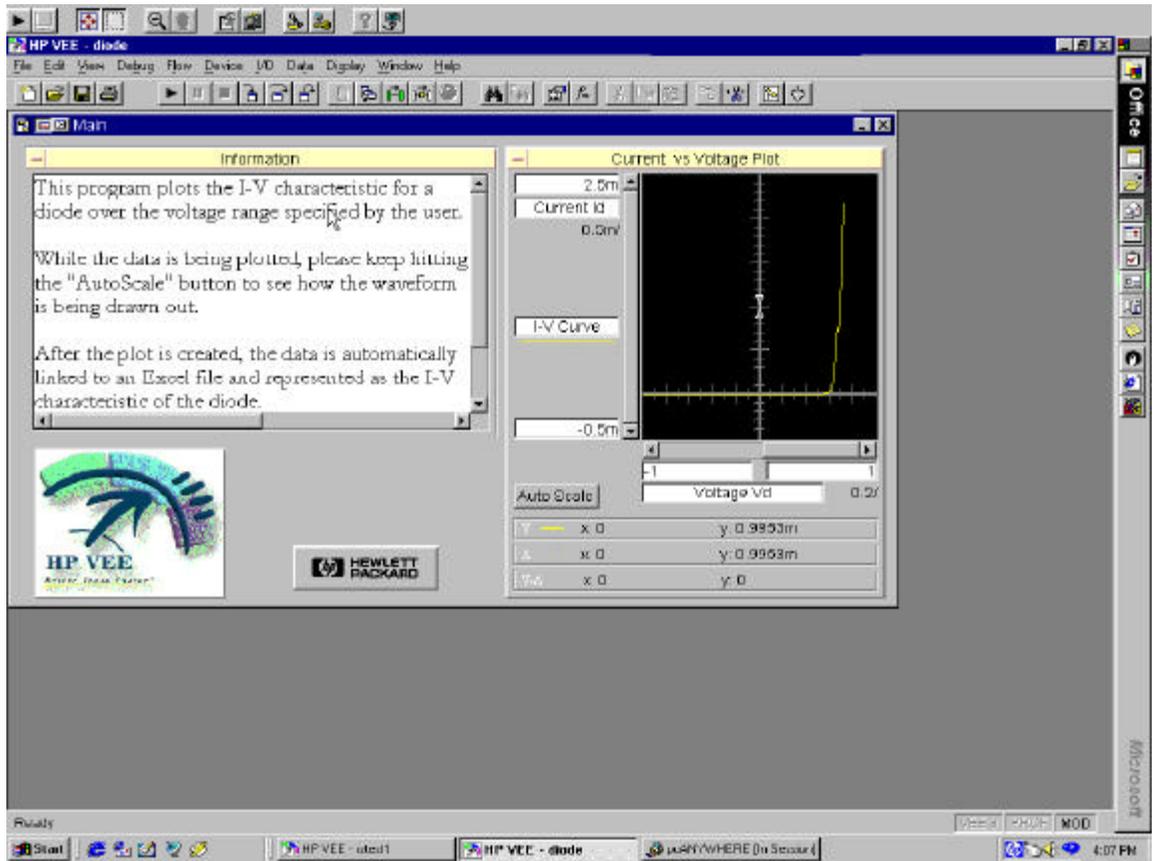


Figure 9.3

10

FUTURE ENHANCEMENTS

In designing the remote education course material, the instructor might follow some strategies for presenting questions to students. Like for example, when a student gives the wrong answer he is informed of his mistake and provided with a clue as to the correct solution. Successive clues could be given at progressively lower levels of difficulty. Because there is no comprehensive logic of program writing, the efficiency of this and other strategies would need to be evaluated in terms of their ability to promote student learning.

The problem of program writing could if desired, be approached from the opposite direction. Rather than the teacher attempting to anticipate problems that the students are likely to have, the instructor might, over a period of time, develop a file of the actual questions raised by students as the course content is covered. The program, which was developed, could provide explanations, illustrations and practice exercises relating to the student questions. In future classes each student would have access to the computerized question-and-answer bank.

A more idealized form of the program would exist if the student was completely free to ask the computer any question about course content that came into his mind. To accomplish this the computer would have to be programmed to make judgments on the content and meaning of any free response question pertaining to the course. Technically there are ways of

approaching the problem, although a true question-and-answer program appears somewhere in the future.

SUMMARY

In the distance education program, the purpose of a remote lab is the same as that of a traditional lab: to give the learner an opportunity to remotely practice newly acquired knowledge and skills.⁴ Some of the features that remote labs must support in the distance-learning environment include:

- ❖ Allowing access to lab equipment via a computer.
- ❖ Connecting to real or simulated training environments.
- ❖ Tracking progress and reporting back to the learner the tasks that need to be completed to finish the lab and/or some equivalent form of feedback.

Advantages to the Students

❖ Risk free

Students learn by trial and error with no fear of embarrassment or harming real equipment or tools.

❖ Hands on

Students really only "learn by doing". Although this may sound cliché, it is true.

❖ Practice to perfection

⁴ Johnson, Clemens M. *Educational Uses Of The Computer: An Introduction*. Rand McNally & Company, 1971.

Learners can apply their knowledge and skills until they reach mastery; or repeat labs as desired, until complete proficiency is reached.

❖ Self-assessment

Learners can assess what type of additional training or reading-up is needed before moving on to new topics or examinations.

❖ Augments classroom training

Learners are offered an opportunity to practically try out what they have learned in the classroom.

❖ Flexible availability

Choice of the block of time that fits best into the student's schedule to perform the remote labs means total flexibility.

❖ Need Based Skills

Each remote lab focuses on a specific skill, so learners are free to select one that best fits their needs.

Advantages to the Organization

❖ Low cost

Once a remote lab is developed, learners can access it over the network; no instructor is needed, nor are classroom facilities.

❖ Focuses on skills

Remote labs can focus on the specific skills needed for each particular student in different educational organizations.

❖ Repeatable

Low cost and high availability make the repetition of remote labs, or their use as refresher courses, very cost effective.

Limitations

❖ Not Live Classroom

Limited coaching and guidance as compared to live classroom events.

In a nutshell, the remote experimentation environment can be thought of as a means of "learning without limits".³ It is designed to overcome many of the limitations of traditional classrooms. There are no limitations on time, place, or pace of learning; or on the ability to form a collaborative learning community that includes a diversity of people: different ages, different life experiences to share, from any part of the world.

³ Hiltz, Starr Roxanne. *The Virtual Classroom: Learning Without Limits Via Computer Networks*. Ablex Publishing Corporation, 1994.

DISCUSSION

Overall, there is no basis in the research for saying that students learn more or less from computer-oriented teaching than from classroom teaching. This does not mean that under some conditions of teaching some students do not learn more of a certain subject matter or skills from one medium or channel of teaching than from the other. But the results of the broad comparisons say that there is, in general, no significant difference.

Educational Outcomes

Each medium of communication has its advantages and disadvantages. Outcomes seem to be related more to the particular implementation of an educational use of a medium than to intrinsic characteristics of a medium. Implementations that capitalize on the strengths of a medium, and that circumvent or adjust for its limitations, can be expected to be successful in terms of outcomes, while other implementations will be relative failures. Certainly, we know that some courses offered in the traditional classroom are more successful than others, and that this can be related to variations in the teaching skill and style of the instructor.

Thus it is not that "media do not make a difference", but that other factors may be more important than or interact with communication medium in affecting educational outcomes for students. A primary goal in studying a new medium of communication for educational delivery must be the identification of effective and ineffective ways of using it.

Human Factors

In the remote learning environment, some recognition needs to be given to purely human psychological parameters. There are certain human performance limitations which determine how people learn and hence will affect the design of distance education programs. The study of such performance limitations is the domain of the human factors field, also called ergonomics. The human factors literature is voluminous and covers a vast collection of topics varying from physiological parameters to decision-making and reasoning abilities. It applies to remote education in many ways.⁵

A great deal of human factors research has been done on the use of computer and communications technology. The focus of this research is on the design of highly usable interfaces which require minimal learning and result in minimal errors. Clearly, this is of concern in the design of any remote education program that relies on technology for delivery. Other human factors research relates to the design of visual displays. For example, the effects of color have been studied extensively, as well as typography, display speed, screen size, etc.

Memory limitations are another popular area of human factors research. One of the classic principles of human performance is that short-term memory is limited to seven plus or minus two chunks of information. This means that most people can retain between five and nine things in memory at one time. In terms of organizing lessons or experiments, or presenting information on a screen, this is an important guideline to follow.

⁵ Kearsley, Greg. *Training For Tomorrow: Distributed Learning Through Computer And Communications Technology*. Addison-Wesley Publishing Company, 1985.

Because it is usually intended to provide answers to practical problems, most human factors research is very specific to a particular situation or context. For this reason, it is difficult to describe general principles that can be broadly applied to distance learning. However, for any given learning environment and technology, there are undoubtedly findings of value in the human factors literature. Knowledge of relevant performance limitations can help predict where problems are likely to occur or what kind of errors will be made while learning.

CONCLUSION

What is intended by the use of remote experimentation is that the pupil should acquire methodology, developing a spirit of criticism and initiative, forming his capacity for synthesis and analysis, obtaining a decisive and imaginative character and reaching a capacity for group communication and work.

We cannot expect miracles from this new method of distance education. Only practice will prove if this technology has brought revolutionary changes in the field of teaching laboratory experiments. This does not mean that the traditional classroom form of teaching is not necessary. On the contrary, a judicious combination of the two forms of learning would complement each other very well.

The Changing Face Of Instruction

If remote learning programs come to play as important a role in education in the coming years as is expected, the nature of instruction will change significantly. Learning shifts from a largely passive role in the classroom to active participation due to interactive instruction. Scheduled classes give way to individualized learning programs. Distance learning is primarily learner controlled rather than teacher controlled. Instead of text-based instruction, it is presented in electronic forms. Distance learning tends to focus on higher-level learning skills (i.e., problem solving, decision making) rather than lower-level skills such as memorization or concept learning. Distance education provides specialized learning experiences instead of generalized instruction aimed at average students. Traditional instruction tends to be content oriented whereas distance learning is performance oriented. Collectively, all

these changes add up to a new face for education and training. Computer and communication technologies continue a trend that has been going on for centuries toward more effective methods of learning and teaching. By harnessing the power of computer and communications technologies, it will allow more people to learn in a more effective and enjoyable manner.

To conclude, it can be said that the driving force of innovating remote education, and education in general, is not 'hardware' or 'software' or 'courseware'... but 'HEARTWARE'. It is this strong commitment to education that lies deep in our hearts that is truly the starting point for the creation and development of new educational media.

REFERENCES

- [1] Connor, Kenneth A. and Podowski, Michael Z. *Distance Delivery Of Undergraduate Laboratories*. December 1999. <http://hibp7.ecse.rpi.edu/~connor/DistanceLab.PDF>
- [2] Helsel, Robert. *Visual Programming With HPVEE*. Hewlett Packard Professional Books, Prentice Hall PTR, 1997.
- [3] Hiltz, Starr Roxanne. *The Virtual Classroom: Learning Without Limits Via Computer Networks*. Ablex Publishing Corporation, 1994.
- [4] Johnson, Clemens M. *Educational Uses Of The Computer: An Introduction*. Rand McNally & Company, 1971.
- [5] Kearsley, Greg. *Training For Tomorrow: Distributed Learning Through Computer And Communications Technology*. Addison-Wesley Publishing Company, 1985.
- [6] Lovis, F. *Remote Education And Informatics: Teleteaching*. Elsevier Science Publishers B.V. (North Holland) IFIP, 1988.
- [7] Shen, Hong; Xu, Zheng; Dalager, B.; Kristiansen, V.; Shur, Michael S.; Fjeldly, Tor A.; Strom, O.; Lu, Jian-Qiang; and Ytterdal, T. *Conducting Laboratory Experiments Over The Internet*. IEEE Transactions On Education, August 1999.