DEVELOPMENT AND EVALUATION OF COMPUTER-BASED LABORATORY PRACTICAL LEARNING TOOL

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ABSTRACT

Effective evaluation of educational software is a key issue for successful introduction of advanced tools in the curriculum. This paper details to developing and evaluating a tool for computer assisted learning of science laboratory courses. The process was based on the generic instructional system design model. Various categories of educational software that can be used for laboratory courses are described. The use of computer based resources in supporting the teaching of electronics science laboratory course is described where the course has been enhanced to develop skills in experimental design, data analysis and links to theoretical parts of the subject.

INTRODUCTION

Rapid technological change is an inevitable aspect of modern life. Computers are the overwhelmingly dominant example of this technological change in the way we do things, especially in the sciences. Science classrooms in general, and electronics classrooms in particular, are rushing to embrace the computer as an educational tool. This is a reasonable adaptation for a field that sees computers used in every aspect of its application. The computer can be found in every electronics research lab as an integral part of the lab.

With computer-based tools becoming more affordable we have the expectation that time and distance factors will have less impact on the way instruction is delivered to students of such subjects. While laboratory-based training does not seem to be due for replacement by software model-based training in the foreseeable future, instructional software can be used as a complementary tool during laboratory work. For instance, the theoretical background of the laboratory work can become available to the students through multimedia software, preparation of the laboratory exercises and contacting of the laboratory experiments can be supported by computer systems, used for collecting data, processing measurements, testing wiring and equipment configurations, simulating behavior of equipment etc.

It is hoped that computer-assisted teaching can help us deliver a deep and solid education to the specific subject, increasing the interaction between the instructor, student and the concepts under investigation. Appropriate use of this educational software allows students to build knowledge by giving them opportunities to explore the equipment to be used beforehand in a safe for them and the machinery way, interact with it, experiment, problem-solve, and collaborate. Interactive, multimedia experience cannot replace the real laboratory work but can enhance the learning process of many students, help them find the relation between the theoretical principles and the observed behavior in an easy and intuitive way.

Software tools in laboratory courses

There are various categories of educational software that can be used in Laboratory Courses, grouped by the specific task, which they are focused on:

Multimedia presentations and tutorials. These tools provide a theory background to the student, enhanced by the use of different media such as sound, video, text and hypertext, pictures and animations. These presentations aim at providing the students with a realistic description of the topic and enhance greatly their interest.

Problem solving and self-examination systems. They give the opportunity to the students to evaluate the quality and amount of acquired knowledge relative to the subject studied, and unveil their weaknesses and misunderstandings.

Laboratory preparation software. This class of educational software provides information about the structure of a laboratory exercise, gives the theoretical background, analyzes the physical models underlining the equipment used, discusses the tasks which the student has to accomplish and provides tools or guidelines to collect the data, helps them come to conclusions and explain their observations.

Laboratory work support system. It involves deep integration of software system and the laboratory equipment. The objective is to automate the execution of the laboratory work. This improves the classical way to perform science laboratory work, which presents the following disadvantages:

a) A lot of time is spent by the students for preparatory activities like wiring and by the supervisor for checking the wiring.

b) Long manual measurements result in shifting attraction away from the lab objective.

c) Measuring instruments are protected against accidental damage

d) Lab reports, containing measurement analysis, are prepared by the students after leaving the laboratory. Consequently, there is no possibility for checking or repeating measurements that could have contributed to deeper understanding of the subject.

e) Group work in labs, results in not effective participation of all students during the laboratory work.

Modeling and simulation This type of educational software makes use of computer models in order to simulate the behavior of the system or process under study, substituting the laboratory equipment. This way it is possible to repeat an experiment many times, comparing the findings with the model-based values.

We can expect that a complete laboratory-educational software can cover most of the above functionality, maximizing the interaction with the student and enhancing various phases of the educational process. The automation of the experimental bench through introduction of a combination of the above systems, improves the quality of education, offering important advantages such as:

a) The students devote their time to fruitful discussion and useful observations, having the possibility to analyze directly the measurements, repeat some of them, compare with theoretical or simulation results etc

b) The students are concentrated on understanding fundamental concepts and not performing tedious wiring and measurements

c) The students can be introduced to interrelated disciplines, such as automation and control, data acquisition etc

e) Minimization of failures due to wrong wiring

F) Minimization of the effort needed by the laboratory support staff.

G) New possibilities on continuous education, distance-learning, collaboration with industries and training of industrial personnel etc.

A case of laboratory educational software

Author has designed as an integrated laboratory support system. The first prototype was built to support students conducting laboratory work, aims at helping the student study the background concepts required for preparation and doing the relevant laboratory exercises. The self examination module gives the opportunity to the student to evaluate the progress, and discover possible weaknesses and misunderstandings. The system can also be used during the laboratory exercise for collecting measurements, preparing graphs and reviewing the progress of the laboratory work at run time.

Typical system usage

The system is made up of 4 modules, described briefly in the following. The main screen layout is shown in figure 1 .

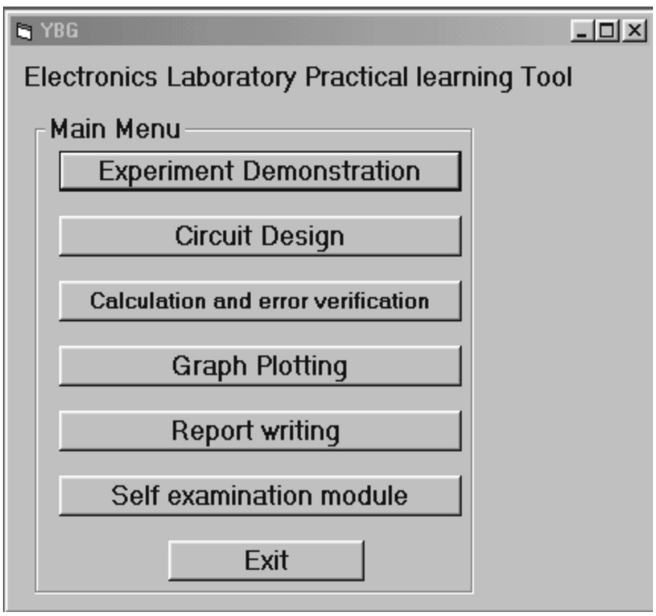

Fig1 : Main menu screen layout.

Background theory exploration

Here the user can review the background theory presented in the same form as the laboratory hand-outs. This module has been incorporated in the system for completeness sake, so that the student will not need to go back to the printed material in order to obtain information about the laboratory and the background theory, shown in figure 2.

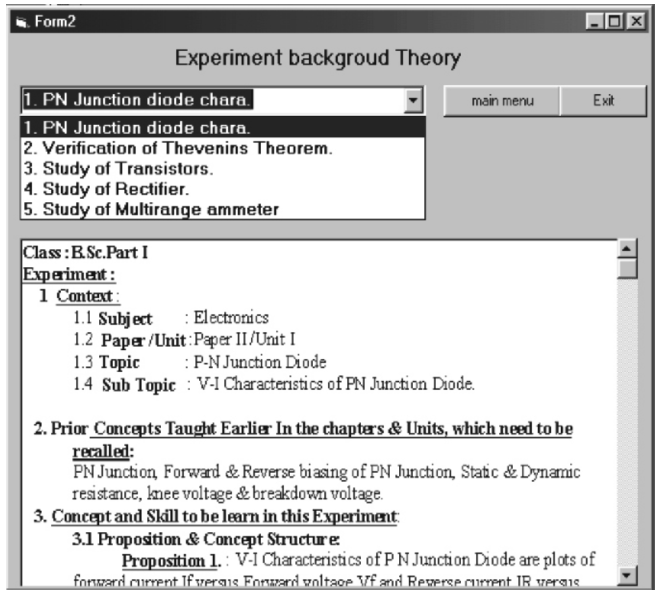

fig.2 : Background theory exploration module.

Simulation

Using this module, the student can become familiar with the equipment connectivity diagram, which student will have to build during the laboratory exercises (selection of measuring instruments from a library and comparison of the diagram with the effected connections). The student can explore and navigate an interactive diagram, shown in figure 3, from which can receive feedback and further information, by simply clicking on each part. The student can also experience different equipment connectivity configurations and load variations.

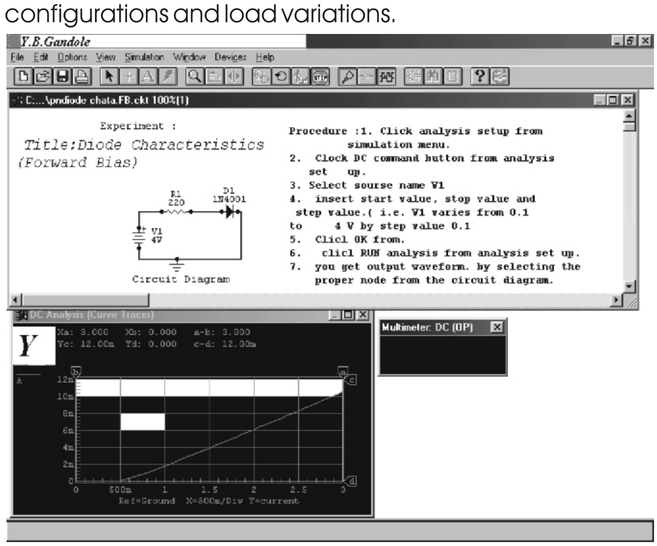

fig.3 : Simulation module.

Run-time lab module

In this module, which can be used immediately before the exercise execution and during the exercises in a computer next to the equipment, the student can receive specific directions about the steps required to carry out successively the lab and extensive explanation of what each step requires in order to be accomplished. Also the students can store measurements taken and process the measured values in a custom spreadsheet provided.

Direct comparison of the experimental measurements with the model values can be done, in order to ensure that the process is correct (shown in figure 4 (a) and (b)).

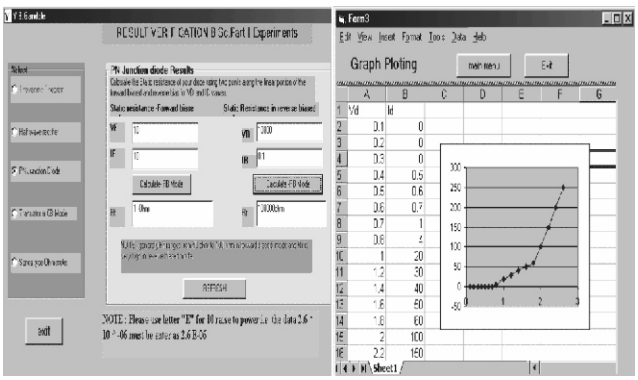

fig. 4 : Runtime module.

Testing methods

These are tests, measuring system performance against pre-defined criteria. Typically we observe individual users performing specific tasks with the system. Data are collected on measured performance. For example, time required to complete the task or number of errors made. Selection of appropriate users and representative tasks is essential. Also a properly designed and organized usability laboratory is important. The most widely accepted usability testing techniques, suitable for laboratory software, are:

Thinking Aloud Protocol is a technique widely used during usability testing. During the course of a test, the participant is asked to vocalize his or her thoughts, feelings, and opinions while interacting with the software, performing a task - part of a user scenario. While this technique is particularly difficult to use with young students, who are distracted by the process, it can easily be applied at College level and Higher Education Laboratory courses.

Co-discovery is a type of usability testing where a group of students attempt to perform tasks together while being observed, simulating typical educational process, where most people have someone else available for help. This can be particularly suitable in our case if the laboratory is done by groups of students.

Questioners and Interviews based protocols These techniques instead of waiting for the students to vocalize their thoughts, prompt them by asking direct questions about the system. Their ability (or lack of) to answer questions can help evaluators decide about parts of the system interface that present difficulties for the users.

Performance measurement. Some usability tests are targeted at determining hard, quantitative data. Most of the time this data is in the form of performance metrics. E.g. required time to execute specific tasks.

Finally **in-field studies** concern observation of the users performing their tasks in their usual environment of study. These techniques have the advantage of the natural user performance and group interaction however present limitations in terms of measuring performance, since the necessary testing equipment cannot be used in a typical workplace.

Evaluation technique

The questionnaire has been designed by investigator to evaluate the quality of prototype module. This questionnaire contains 13 statements refer to the technical aspects of the software. Their aim was to evaluate its technical adequacy to the learning objectives of the program. They deal mainly with questions related to the general structure of the product navigation, interactivity, design and other aspects that can favor or hinder the learning process. Overall 27 statements refer to curricular design aspects, usefulness and intend to evaluate the integration capacity of the program in the learning process of an electronics practical.

Responses of students were in five-point scale. The 45 students, offering electronics subject at B.Sc. level were selected randomly for this piloting. The students were divided into three batches. Initially the investigator demonstrated the each module of the software using LAN for each batch and they asked to operate the each module of the software freely. Finally the questionnaire was given to every student and they asked to write '1' for very bad or NO, '2' for bad or sometimes, '3' for acceptable or average, '4' for good or almost always and '5' for very good or Yes. The students who respond either 4 or 5 were grouped together which indicated the good quality of computer software. On the other hand the students who responded either 3, 2 or 1 are grouped together which indicated the poor quality of software and requires modifications. It was later on converted into percentage. The consolidated list of percentage for every statements was given in table 1.

From the analysis of piloting it was found that the development of computer software programme for laboratory communication was very good.

Conclusion

This paper has described one potential method for developing and testing a prototype computer based

instruction module for electronics science students. The main features of the software were presented. Special emphasis was given in the usability evaluation process of the software. A methodology for evaluation of the software of this nature was outlined.

Item no	Statement	%of positive response	%of negativ e respons e
A	Technical-Instructive Adaptation :Interface Design (Screen design)		
1	The quantity of colour on screen is adequate for the sort of information contained	84.44 %	15.56 %
2	The quantity of the images is adequate for the sort of information contained	77.78 %	22.22 %
3	The sound quality level is adequate for the sort of information transmitted	71.11 %	28.89 %
4	The quantity of graphics and images is adequate for the sort of information transmitted	82.22 %	17.78 %
5	The resolution of graphic and images is adequate for the sort of information transmitted	82.22 %	17.78 %
6	The text presentation on screen is adequate for the information transmitted, Access and control of the information	97.78 %	2.22 %
7	The student has control over different parameters of presentation (colour, sound level, etc.)	82.22 %	17.78 %
8	The program facilitates the paper printing of selected information by the student	95.56 %	4.44 %
9	The program facilitates the navigation through the contents	88.89 %	11.11 %
10	The program gives the student the possibility of modifying the information contained.	84.44 %	15.56 %
11	The interaction tools (buttons, menu, commands) facilitate the learning process	86.67 %	13.33 %
12	The program, in general, is easy to use	88.89 %	11.11 %
13	It is easy for the student to learn how to use the program	88.89 %	11.11 %
14	The running of the program is adequate (there are no bugs which block it)	86.67 %	8.89 %
B	2.- Didactic or Curricular Adaptation		
B1	Learning contents		
15	Are clearly presented	93.33 %	6.67 %
16	Emphasize the most important things	77.78 %	22.22 %
17	Are sequenced	93.33 %	6.67 %
18	The information is updated	88.89 %	11.11 %

19	Are enough to achieve the objectives	80.00 %	20.00 %
20	Are beneficial to the improvement of attitudes	91.11 %	8.89 %
21	Are extra-laboratory activities	91.11 %	8.89 %
22	Are free of grammar or spelling errors	95.56 %	4.44 %
B2	Learning activities		
23	Require different levels of mastery	8.89 %	91.11 %
24	Follow a logical sequence in relation to the objectives	84.44 %	15.56 %
25	The number of different activities is enough	80.00 %	20.00 %
26	Allow different tries for answering	91.11 %	8.89 %
27	Examples of the activities to be done are shown	93.33 %	6.67 %
28	Examples are clear and adequate	93.33 %	6.67 %
B3	Evaluation		
29	The program is constantly evaluating the student's output	84.44 %	15.56 %
30	Shows the student the errors he/she has made	82.22 %	17.78 %
31	Provides specific help for the student's errors	91.11 %	8.89 %
32	The feed-back is immediate	88.89 %	11.11 %
33	The feed-back is motivating for the student	86.67 %	13.33 %
34	The feed-back provides clear and significant information	88.89 %	11.11 %
35	Facilitates self-correction	86.67 %	13.33 %
36	Constantly informs the student about his/her output	82.22 %	17.78 %
B4	Motivation		
37	The program increases the active involvement of the student on the laboratory task	91.11 %	8.89 %
38	Students show a better interest in learning practical	93.33 %	6.67 %
C	Usefulness		
39	Use it as self-instruction material	88.89 %	11.11 %
40	Use it as complementary laboratory material	68.89 %	31.11 %
41	The program makes it possible for the students to work in groups of two or three	71.11 %	28.89 %

The positive responses by students and staff to the material tested at the four colleges affiliated to Amravati University , Amravati (India) ,suggests that the difficulties of producing high quality video on a PC and meaningful interactivity (self-learning and self assessment) have been overcome. The challenge now shifts to Universities in order to facilitate a student culture in which all students have a CD ROM PC on day one of their degree course, a teaching and learning culture in which students can proceed at their own pace, laboratory experiences where students develop both practical and presentational skills, and staff development facilities whereby staff can be enabled to produce the new IT materials for the 21st century.

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References

1. Angelidis V.G.: "*Incorporating Instructional Feedback in Elec. Eng. Laboratory Experiments -An Example*", *IEEE Trans. on Education, Vol. 40,(1), February 1997.*

2. Avouris N. et al. *Educational Software Evaluation Guidelines, Technical Report, Working Group on Educational Software Evaluation Procedure , Pedagogical Institute, Athens, 1999.*

3. Avouris N., Tselios N., *Conclusions of Heuristic Evaluation of Educational Software:Application in Laboratory Instructional System, Proceedings Infoworld98, EPY Publication, Peireas, 1998.*

4. Dix A., Finley J., Abowd G., Beale A., *Human-Computer Interaction, Prentice Hall, 1998.*

5. Fitzpatrick R, Higgins C., *Usability Software and its*

attributes: A synthesis of software quality, European Community Law and HCI, People and Computers XIII, pp. 3-22, Spriger-Verlag, London, 1998.

6. Preece J. et al., *Human Computer Interaction, Addison-Wesley, 1994.*

7. Rubin, J., Handbook of Usability Testing, *J. Wiley & Sons, New York, 1994.*

8. Schneiderman B., *Designing the User Interface, Addison Wesley, 1998.*

9. Squires, D., Preece, J., *Predicting quality in educational software: Evaluating for learning, usability and the synergy between them, Interacting with computers, 11, pp.467-483, 1999.*

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1. Awarded the Late Shri Laxaman Kashinath Patankar Prize and Ramanujan Mathematics Gold Medal, V.K.Khandekar Gold Medal & Late Y. G. Shiledar , A.B. Guruji of Yavatmal Gold Medal .for obtaining the highest percentage of marks in the subject Mathematics at the 74 th convocation held on 5th July 1986 by Nagpur University Nagpur. Also obtained the fourth rank in merit list.

2. Attended as well as participated in seminar and course on "OFFICE AUTOMATION WITH PERSONAL COMPUTERS" supported by Indian Society of Technical Education -Continuing Education Projects; held at Amravati on 13th & 14th April 1991 and presented a Paper on " *CENTRALISED DATA BASE SYSTEM AND DISTRIBUTED DATA BASE PROCESSING SYSTEM AND DATA COMMUNICATION* "

3. Attended as well as participated in national seminar on "Information Technology - Current Trends ". Supported by U.G.C. held during 22-24 April 2000; at the Department of Computer Science and Engg. Amravati University Amravati. & Presented a paper entitled "*INFORMATION TECHNOLOGY FOR MASSES AND GLOBALISATION*".

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