

# An Integrated System as a tool for complex technologies learning

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**Abstract**—This paper describes a integrated computer-based learning system improving engineering teaching and learning of complex technologies. It combines a tutorial with a virtual laboratory and a self assessment tool to achieve a self-learning system. The tutorial is a hypermedia document linking different concepts of Electronics technology and combining them with a virtual laboratory. This virtual laboratory is made up of a set of virtual experiments with a user-friendly graphic interface and interactive simulated electronic instruments relating practical and theoretical concepts. The self assessment tool combines a test with each experiment of the virtual laboratory. The whole system matches the constructivist theory and constitutes an interactive computer-based complex tool.

**Keywords**-component; integrated learning system; computer aided learning; virtual laboratory; self assessment too;.

## I. INTRODUCTION

Engineering teaching and learning has turned very difficult because present technological solutions including many interrelated concepts tend to become very complex [1] [2]. Consequently some engineering education experts [3] [4] claim that it is necessary to develop new education methods using information technology tools to improve teaching and learning. Using these methods it is possible to combine theoretical and practical activities [5] [6] in order to learn technology synthesis methods using actual products as working examples [7]. There is also a general agreement about the need of new teaching and assessment strategies to enhance competence-based learning [8]. The whole system matches the constructivist theory [9] [10] [11] [12] and constitutes an interactive computer-based complex tool enhancing competence based learning.

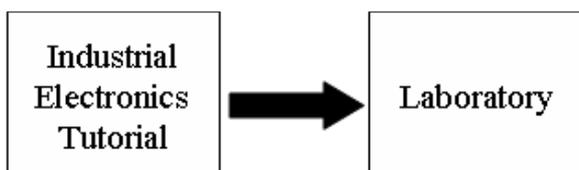


Figure 1. Learning process of complex technologies at present

At present, complex technologies learning comprises two steps. First, the students learn theoretical concepts attending lectures and studying a tutorial book and second, they perform a set of tasks in a laboratory. However, this process has several drawbacks:

- Tutorials included in a book do not give enough information about the dynamic behavior of the different types of circuits and systems.
- Students have insufficient knowledge about commercial components, assembly techniques and measurement instruments. Assembly errors and component damage are common during laboratory classes.
- Students do not know if their knowledge about theoretical concepts is good enough.
- Students have no experience on testing different components behavior.
- It is not suitable for asynchronous distance learning

This paper describes a computer-based system improving the engineering education process. This system is called “integrated learning system” because it combines three subsystems (see figure 2):

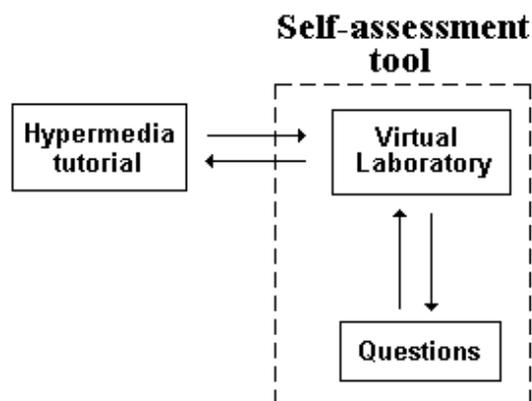


Figure 2. Hypermedia integrated learning system block diagram

A. Tutorial

It is a hypermedia learning system structured into chapters, sections and subsections. The different subsections are associated with one or more virtual experiments through a user-friendly graphic interface and some interactive simulated instruments relating practical outcomes with theoretical concepts. The student can execute each experiment at the point indicated in the tutorial after studying the corresponding theoretical concept.

B. Virtual Laboratory

There are several kinds of virtual laboratories with different application purposes. The virtual laboratory of the integrated learning system comprises a set of virtual experiments. Each experiment is a pedagogical interactive simulation using just a few computer resources and can be integrated with some other software application.

C. Self-assessment tool

This is a computer tool combining one or more tests with each experiment of the virtual laboratory. In each case the student selects what he thinks is the correct answer and the system does not provide the solution but shows him the experiment outcomes, giving the possibility of verifying his answer. In this way he can learn from his mistakes [13].

As an example an “Electronics Integrated Learning System” has been developed including a virtual laboratory and a self assessment tool.

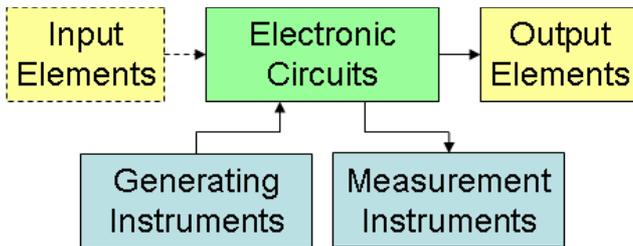


Figure 3. Block diagram for of the interface of the virtual laboratory of the Electronics Integrated Learning System

II. VIRTUAL LABORATORY

The Electronics Virtual Laboratory has the following characteristics:

- A user-friendly graphic interface.
- Interactive simulated instruments with a functionality similar to that of the actual instruments.
- Relates practical with theoretical concepts through a selected set of experiments.
- Each experiment is a pedagogical interactive simulation using just a few computer resources and can be integrated with some other software application.
- Provides destructive experiments which are not possible when using actual electronic devices.
- It has self-test capacity.

- It is scalable to add new performances.

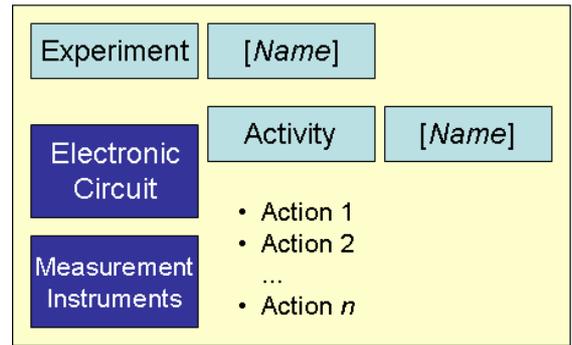


Figure 4. Block diagram of the experiment user interface

The user interface includes the different instruments used in the actual laboratory. These instruments are connected to some suitable test points. Figure 3 shows the block diagram for the user interface of the electronics virtual laboratory, including generating instruments, measurement instruments, input and output elements, and the electronic circuits under test.

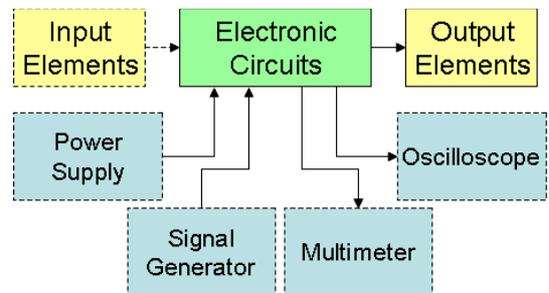


Figure 5. User interface block diagram of the Analog Electronics Virtual Laboratory

Each experiment includes the description of the activities to be accomplished by the student, as shown in figure 4.

The main parts of Electronics are Analog and Digital Electronics, and a Virtual Laboratory has been developed for each one of them.

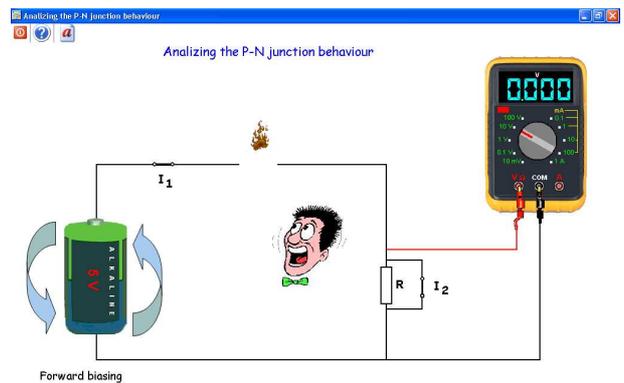


Figure 6. PN junction destructive experiment behaviour using a multimeter

A. Analog Electronics Virtual Laboratory

Figure 5 shows the user interface block diagram of the analog electronics virtual laboratory experiments including a signal generator, a power supply, a multimeter and an oscilloscope. All the experiments use a power supply, and depending on the characteristics of the experiment, one or more of the other three available instruments.

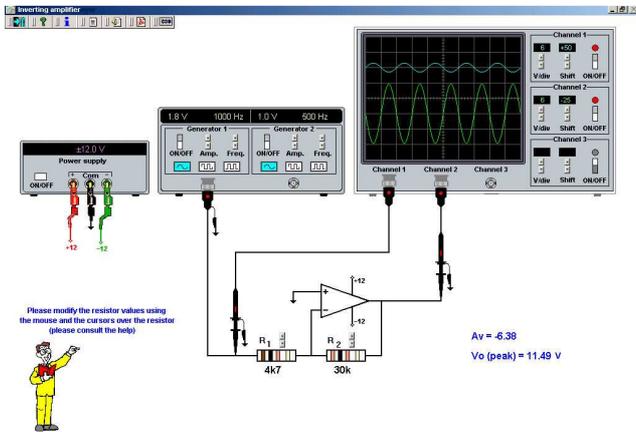


Figure.7 Inverting amplifier experiment using a signal generator and an oscilloscope

The multimeter is used in the experiments where only DC signals are involved. As an example, in figure 6 shows the experiment analyzing the behaviour of the PN junction. This is a destructive experiment where the user can verify what happens when the PN junction is directly biased without a current limiting resistor.

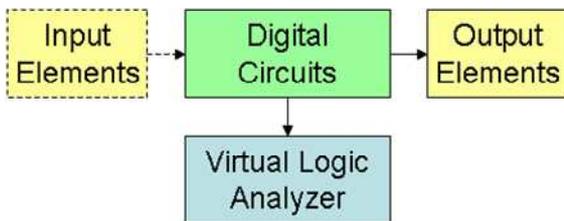


Figure 8. Digital circuits virtual experiment block diagram

The oscilloscope is used when the experiment includes time varying signals. The student can select the type of waveform, the frequency and amplitude of the signal generator output and the scope main parameters. He can also change the resistor standard values using the mouse. As an example, figure 7 illustrates the experiment analyzing the behaviour of an inverting amplifier.

B. Digital Electronics Virtual Laboratory

The digital electronics virtual laboratory (see figure 8) has an interactive graphic user interface including a digital circuit and a virtual logic analyzer to visualize the evolution of the different input and output signals.

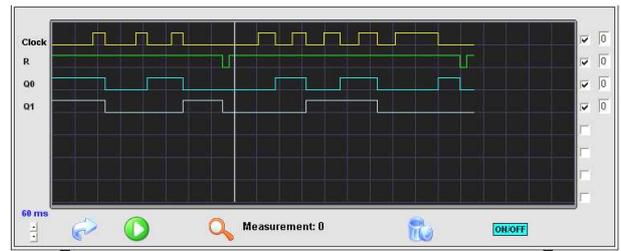


Figure 9. Virtual logic analyzer interface

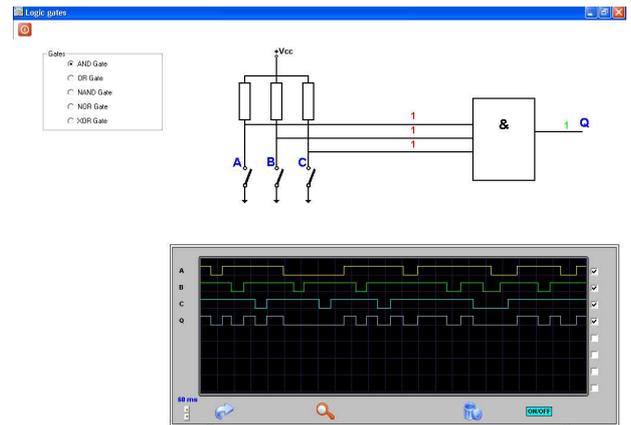


Figure 10. Experiment of the different logic gates

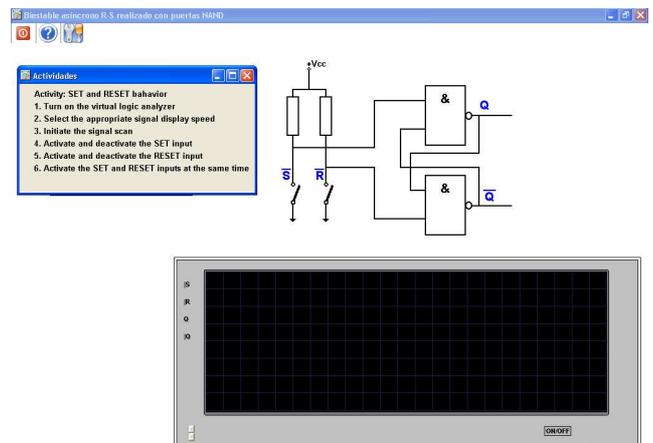


Figure 11. Student interface of the experiment “R-S latch with set priority”

The virtual logic analyzer ( see figure 9) has 8 channels. It works like an actual logic analyzer, including user programmable signal display speed. Signal display can be stopped at any time. In this situation, when the user clicks on the magnifying glass a cursor facilitates signal level reading on any point of the virtual logic analyzer screen. The virtual logic analyzer is a suitable tool to analyze the behaviour of the different combinational and sequential circuits. Figure 10 shows the experiment describing the behaviour of the different logic gates. The student can select the type of gate and the logic

level of the inputs. Figure 11 shows the R-S latch behavior including its activity description.

### III. SELF ASSESSMENT TOOL

The analog and digital virtual experiments can be used by the professor in the classroom but to become a useful tool improving the user self-learning capacity they must be combined with an assessment tool.

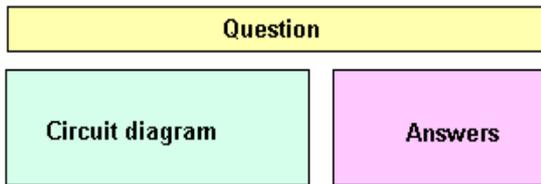


Figure 12. Assessment tool user interface block diagram

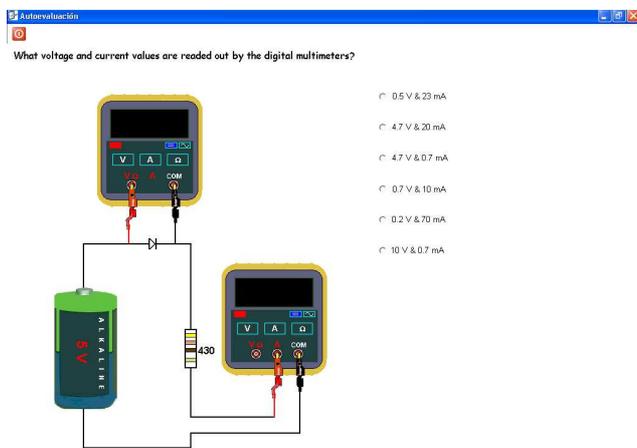


Figure 13. Example of the user interface of a self assessment question

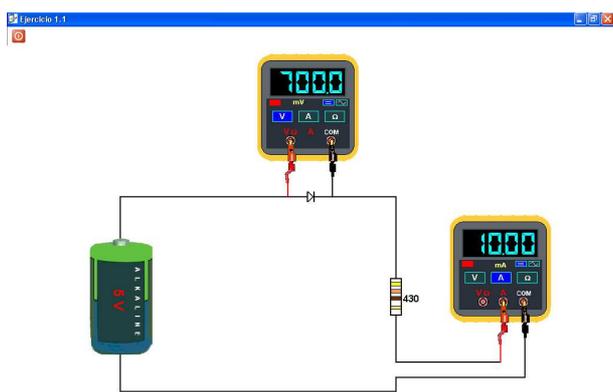


Figure 14. Executing the experiment after answering the question

As shown in figure 13, after studying the hypermedia learning system combining the tutorial and the virtual

laboratory, the student executes the self assessment tool. This tool is a set of multiple choice questions. Figure 12 shows the self-assessment tool user interface block diagram combining one experiment schematic, one question and the list of the possible answers. The student must select the answer that he thinks is correct. The tool does not give him the correct answer but it presents the experiment asking him to execute it to verify if the answer is correct. In this way the student has the opportunity of executing the experiment before giving the definitive answer. This process constitutes a double assessment using not only the question but also the experiment.

Figure 13 shows, as an example, one question about the semiconductor diode. Answering this question the student demonstrates his expertise about the semiconductor diode behaviour when it is forward biased. The student must choose one of the possible answers and then the tool executes the correspondent experimeng. In this way the student can make voltage and current measurements again to verify if his answer is correct in the same way as in an actual laboratory (see figure 14).

### IV. CONCLUSIONS

The integrated learning system described in this paper is an enhanced active learning rich environment [11] increasing the self learning capacity of students. The virtual laboratory is structured as a set of learning objects and it can be combined with different tutorials. The self assessment tool can also be integrated with some interactive learning management system such as for example Moodle.

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