

INTERACTIVE CLASSROOM FOR DSP/COMMUNICATION COURSES

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ABSTRACT

In this study, we present a new classroom environment to conduct digital signal processing and communication systems courses. Key features of the model are the collaborating instructor embracing students, a smart classroom equipped with a "Whiteboard" and advanced telecommunication networks, electronic textbook, and other resources, World Wide Web (WWW), Matlab, and other on-line tools. The underlying assumptions of the educational process are teambuilding instead of independent learning, collaborating/supervising instructor, lateral curriculum instead of a vertical curriculum, and idea-to-product design concept. We will present a sample lecture in the proposed interactive classroom, where the concept of eye diagrams in regenerative repeaters will be presented from the first author's text using matlab and WWW.

1. Introduction

Academic institutions, research organizations, and industry worldwide have been engaged in discussions and curriculum development activities since early nineties to address the needs of the digital signal processing and telecommunication engineers of the Twenty-First century.

These discussions stem from the fact that the bulk of the current instructional model has not changed since medieval times, when the practice of blackboard usage began for delivering algebra and astronomy lectures in particular. The curricula at schools have been often frozen for many years or very slowly changing. For instance, it can take up to two years for a new course to be fully incorporated into the ECE Program at SDSU and many other US schools. The instructor was always in the center stage disseminating knowledge in broadcast mode. The students have been mostly passive receivers except during performance evaluations in the form of homeworks, projects, and tests. It is a common practice to drop one or more of these when the class sizes are large. Achievements by individuals have been the norm without any room for team building. This model of a classroom is shown

in Figure 1. The classroom walls are very solid and often impenetrable. The teacher has a boundary around him and the blackboard is almost totally in his domain. The feedback has been normally an afterfact in the form of course/instructor evaluations and alumni/industry input.

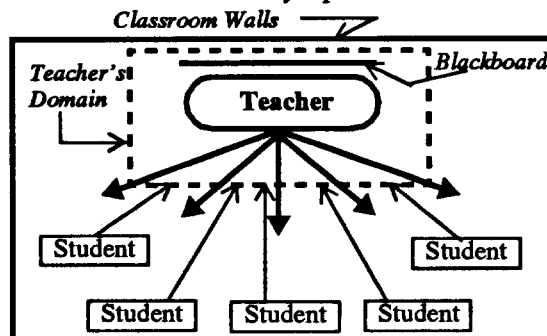


Figure 1. Teacher-Centered Instruction Model.

This has worked satisfactorily until the present information explosion, more precisely, until the low-cost, high-volume, and on-line access to vast information banks using personal computers and advanced communication networks. As the job functions are rapidly changing and expanding all the time, a number of emerging technologies find wide range of innovative applications, and global competition is intensifying everywhere, engineering work force will have to be trained quite differently than before.

Towards that end, it is essential that the overall education process have to be overhauled including the curriculum, the classroom, the roles of the teacher and students. Since the information processing using computers and the telecommunications revolution are taking place around the DSP and CommSys engineers, it is even more critical for them to be better prepared for the Twenty-First century.

There has been a number of special sessions in previous ICASSPs and IEEE Journals on this [1-4]. These presentations and publications cover a range from conceptual models of ECE curriculum to undergraduate digital signal processing laboratories, from entry-level courses to virtual lab environments using advanced network-based tools (SPEC), and finally, from the contents of DSP/Communications courses to

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the integration of MATLAB [4] into the curriculum and textbooks.

Here we will point out a few critical observations from the Signal Processing Education Consortium (SPEC) experiment and the SDSU Interactive Classroom project, which we have been working since Fall of 1994.

- 1) Experimental and lateral curriculum needs to replace the existing course sequences based on vertical thinking and full of long chain of prerequisites.
- 2) Students must learn how to take an idea from a conceptual description --often incomplete and fuzzy-- to a product, be an active partner in shaping up their education, and have large horizons to come up with imaginative applications.
- 3) Independent learning --often isolated and full of frustrations-- have to be replaced with a process based on teambuilding.
- 4) Analysis and decomposition approach --teaching circuit theory and electronic devices first-- must be abandoned. Instead, an integrated systems approach must be the norm to expose the students to the "big picture" including the notions and practice of design, product development, prototyping, testing, and manufacturing.
- 5) Products for the "world theater" must be the goal instead of satisfying the needs of a single customer.

First item has been a perpetual bottleneck of curriculum developers in our profession. Long chain of prerequisites --courses on general education, calculus, circuits, electronic components and devices-- have traditionally delayed the DSP and CommSys topics to the final year of the most EE programs in the U.S. In many U.S. EE students generally do not have any chance to complete a turnkey project in these fields during their undergraduate education. Instead, they are forced to learn these either in graduate programs or in the work force under tight schedules and many real-life constraints.

Similar arguments can be made for every item above. However, we would like to emphasize strongly the importance of the last one. In order to succeed in the world arena the engineers of the future have to be trained as world citizens who know foreign languages, but more importantly, who respect different cultures and their business traditions.

In this work, we will propose a new classroom model called "Interactive Classroom." We have been working since the Fall of 1994 at SDSU and in Ege University, Izmir, Türkiye on this concept. Here the key word is the total cooperation among all the components entering into the educational process including the "new teacher," students, physical classroom, texts, computers, advanced communication networks, and information databases.

2. Interactive Classroom

A simple block diagram for this classroom is shown in Figure 2. As it can be seen from the figure that there are several features in this classroom model which can be considered aggressively innovative. The most critical one is the role of the new teacher. The instructor is a very valuable contributory partner in the teaching process. He facilitates the dissemination of information, coordinates the classroom activities, and evaluates the performance. To achieve this, he may have partners connected via the advanced communication networks. (Team teaching).

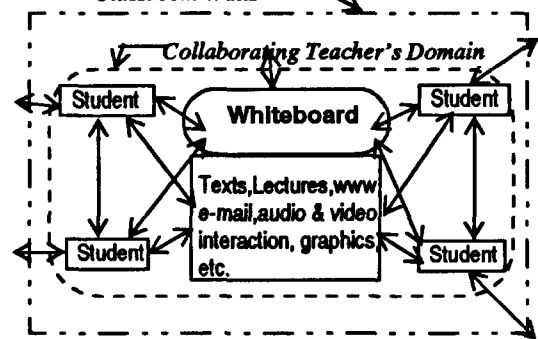


Figure 2. An Interactive Classroom.

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Next, the students are very active partners in this model. That is, they learn outside the physical classroom as well as inside. They use texts, paper and electronic lecture material, WWW, e-mail, video, audio, graphics, and other students to learn a subject or to complete a project. So, the notion of teambuilding is aggressively employed. Of course, the issue of performance evaluations has to be tackled differently than the traditional grading policies².

Third innovation is the physical classroom walls are no longer solid, instead, they are almost porous. In other words, interaction between the people in the room and outside is not only permitted but rather encouraged. For instance, the teams in the SPEC experiments [1-3] are build from students of three different universities, as has been the collaborating professors team.

In the San Diego project, however, the teams are from one campus at this time, but they are encouraged to contact other students, other teams, and other scholars via advanced communication networks. In other words, their reference library is the world arena.

Fourth and final innovation is will be the new definition of a "whiteboard." It is not simply a blackboard painted into

2. One possible grading policy: First sign disclosures agreements between the teacher and the team members. Next, each team member declares his/her contributions. Finally, the teacher and other members confer to come up with a grade. A hidden benefit: Students will have to develop higher work ethics.

white to replace the historical chalk and its dust from the room. It is an active distributed board with a number of components including a physical writing area where instructor and students can put material either by writing, or by projecting, or pulling down from the ever present computer or workstation, or by downloading from information banks over a fast communication link.

We would like to emphasize that the "Whiteboard" is everybody's active property. In other words, whoever has something to offer he/she gets the center stage at a particular time and everybody shares that. In order these innovations to be effective, we realize that we have to develop an infrastructure for this classroom model. The proposed infrastructure development has both hardware and software components. We believe that the hardware requirements can be met relatively easier by modifying present classrooms into "Smart Classrooms" as it is currently being done at SDSU. However, the need to develop a software architecture for this model is the real challenge. Towards that end, we are in the process of defining a Groupware called "OurTool," which will not be discussed in this paper.

3. An Example of a Lecture on Eye Diagrams

Here we will use the WWW page of this course and the Matlab tools to elaborate the concept of eye diagrams, which are very regularly encountered in digital communication and DSP courses as shown in Figure 3. The left hand side of this page has information on the course, its outline, and a movie on digital signals going through a voice-grade communications channel.

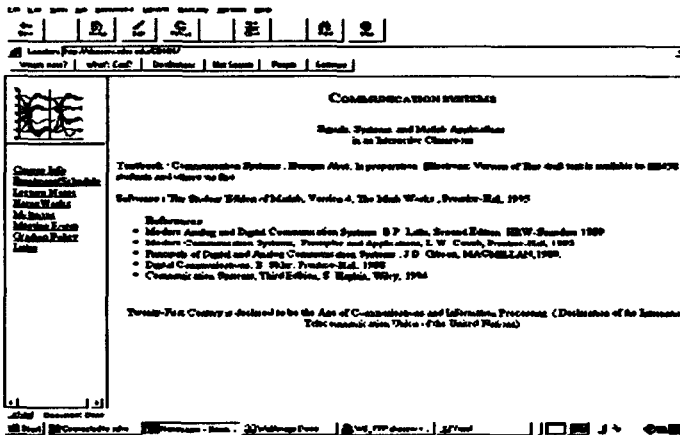


Figure 3. Home Page for our Interactive Course.

Next we go to a lecture on "Regenerative Repeaters" where the basic diagram is turned into an active workspace as shown in Figure 4. The conceptual material will be pulled from the drafts of the book the first author is putting together using Matlab and Framemaker software packages. Each block can be activated to describe its functions, or waveforms

generated or passing through, and spectral description fashioned after the Matlab's Simulink Toolbox Package.

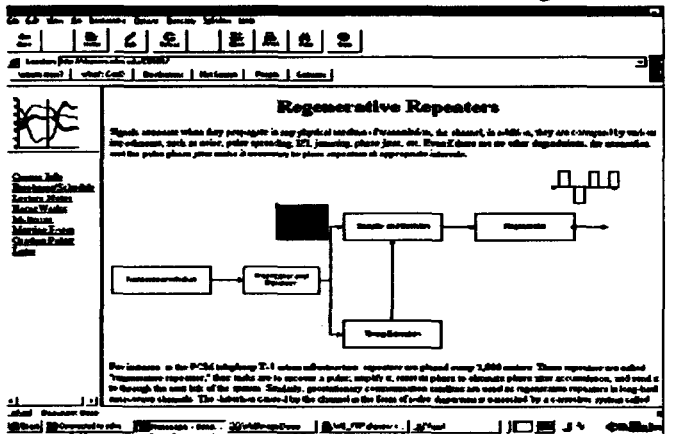


Figure 4. Lecture on Regenerative repeaters.

Using MATLAB Communications Toolbox, we next present the code and the eye diagram for a real-life channel emulation in Figures 5-8. As source we generate a bitstream from a Manchester Code generator. The channel is a 3,250 Hz. voice grade channel. The channel errors are programmable from 10^{-6} to 10^0 , e.i. very clean to 0 dB channel. The student will be able to see the open or closed eye as each bit goes through this system.

We have developed similar tools for our course on Signals and Systems, which is the feeder course for all DSP and CommSys topics at SDSU. We have observed that the performance of our students have continuously improved under the new regime.

4. References

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- [4] G. C. Orsak and D. M. Etter, "Connecting the Engineer to the 21st Century Through Virtual Teaming," IEEE Transactions on Education, pp. 165-172, May 1996.
- [5] The MathWorks, Inc., *The Student Edition of MATLAB Version 4, User's Guide*, Prentice-Hall, Englewood Cliffs, NJ, 1995.

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Figure 1 consists of two subplots. The left subplot shows the wave function $\psi(x)$ in the position basis x for a harmonic oscillator with frequency $\omega = 0.25$. The x-axis ranges from -10 to 10, and the y-axis ranges from 0 to 1. The wave function is a superposition of the first three energy eigenstates, showing a complex oscillatory pattern. The right subplot shows the wave function $\psi(p)$ in the momentum basis p for the same system. The p-axis ranges from -10 to 10, and the y-axis ranges from 0 to 1. The wave function is also a superposition of the first three energy eigenstates, showing a similar oscillatory pattern.