Redesign Of An Undergraduate Analog Integrated Circuits Course

Graciano Dieck, Artemio Aguilar, Sergio Malacón, Manuel E. Macías
Electrical Engineering Department
ITESM, Monterrey México

ABSTRACT

This paper presents a redesign project of the course "E-95-863-Analog Integrated Circuits" that is taken by junior students of the Electronics and Communications Engineering (IEC) Program at ITESM campus Monterrey. This redesign project includes a pedagogical procedure before its implementation with a pilot group of students. This complete pedagogical procedure consists of the following parts: educative intentions, objectives, general contents that includes a contents block diagram, profile of the IEC program, IEC study plan, curricular map showing the courses serving E-95-863 as well as the the courses served by E-95-863, conceptual contents, procedural contents, attitudinal contents, learning strategies and course activities. Some of the learning techniques used in the course are: Interactive exposition of topics (from 16 to 20 hours per semester), Internal group activities (11 during the semester), homework done by external groups (8 during the semester), monthly projects that include report writing and oral presentations done by external groups (3 during the semester), self-study reading assignments and discussion (14 during the semester), office consulting and virtual consulting. The course has been mounted on the "Learning Space®" educational shell that runs under the Lotus Notes® data base program. The shell provides 4 virtual environments available (through the WWW) to students and instructors: "profile", "media center", "course room" and "schedule". For instructors an additional environment, the "assessment", is available in order to develop exams, surveys, and quizzes. The implementation phase using this scheme started in the Fall of 1997. In the Spring of 1998, the course was taught with some improvements after receiving some feedback from students, professors and from the pedagogical associate. In the Fall of 1998, two sections of the course are being taught using this redesign strategy. The implementation results after 2 semesters has shown, on the students, a significant positive impact in 8 procedural and 5 attitudinal contents established in the Mission of ITESM toward the year 2005. However, for the pilot groups of 17 (fall 1997) and 21 (spring 1998) students, the instructor has observed a significant increase in the teaching load compared to the traditional scheme. This is due to the detailed personalized formative and summative evaluations for each student and the continuous attendance to the discussion virtual environment such as "the course room". Further refinements are developed in order to fit the scheme to the typical teaching loads required for the traditional courses at ITESM.

I. INTRODUCTION

In the summer of 1997, the ITESM initiated a project to reengineer the teaching-learning process at the 27 campuses of the system. The project incorporates the fundamental aspects written in the

ITESM´s mission statement for year 2005 [1,2,3,4,5]. In particular, to achieve the desired profile for the ITESM student, each course regardless of the discipline, must incorporate attitudes, values and abilities explicitly written on the mission statement. For instance: honesty, self-study, cooperative learning, self-evaluation, co-evaluation, and critical thinking are, among others, some of the values and abilities distributed during the course. This distribution is performed adding procedural and attitudinal contents to the standard conceptual contents written in the analytical program for the course.

A training and assessment for the ITESM professors were necessary in order to explain the methodology for redesigning courses [4]. This process started in the summer of 1997. The training process consisted in reviewing the pedagogical and cognitive aspects of higher education, including fundamental techniques of collaborative learning, supervised teaching, educational intentions, educational objective writing, evaluation and other related topics. In addition, each professor has didactic and technological project assessors. They follow the project in order to have a relative uniformity in the methodology and in the structure of the redesign projects. For instance, the didactic assessor revise the report written by the professor and he makes sure that the sequence and wording for the educational intentions, general objectives, educational strategies and activities are developed followed the pedagogical approach. The technological project assessor revises the data bases, written over the common platform of Learning Space [1,5], and suggests or recommends improvement actions for making the implementation on the students more friendly and versatile. Although, this process was not easy either for professors and for ITESM, some interesting results have been obtained after almost 2 years form the inception of the project.

The objective of this paper and presentation is to share with you some of the initial results of this effort performed particularly at the Electrical Engineering department. Our department initiated a project to redesign all the analog electronic course sequence consisting of Electronics I, Electronics II and Analog Integrated Circuits. The paper focus on the terminal theory course E-95-863: "Analog Integrated Circuit", taken by junior students of the Electronics and Communication Engineering program (abbreviated IEC for their initials in Spanish). This course has been taught 4 semesters under the new redesigned implementation. The sections of the paper follows the same sequence of the didactic project development for the class: a) educational intentions and general objectives, b) general, conceptual, procedural and attitudinal contents, c) learning strategies, d) summary of activities, e) resources, f) evaluation g) discussion and h) conclusions.

II. EDUCATIONAL INTENTIONS AND OBJECTIVES

The redesign project describes the educational goals with the following statement: "Performing a team effort between the student, who is the center of the learning process, and the instructors, who are facilitators of the teaching-learning process, the following educational intentions are focused during the semester:

1. To supplement integral and formative education.
2. To recognize the value of learning.
3. To promote the critical thinking and reasoning in problem solving.
4. To enhance the self-learning ability.
5. To develop the capacity for searching and selecting information.

6. To recognize the impact of electronics in society.
7. To emphasize the commitment for acting to make things better with responsibility and honesty."

The objectives for the course are described as follows:

A. To comprehend the procedures for analysis and design of electronic devices using highly integrated analog circuits and to develop applications for industrial instrumentation and telecommunications.
B. To recognize the value in using and interpreting information regarding analog integrated circuits for their application in electronic projects developed by industries.
C. To participate in electronic design group projects emphasizing collaborative work, critical thinking, and decision making about different alternative devices using the newly developed concurrent engineering.
D. To use different methods of analog electronics computer simulation for analysis and design of industrial and commercial electronic systems.
E. To investigate electronic devices that directly impact the technological development of our society without compromising either the environment or the industries involved in the manufacturing or using those devices.

Each course module includes a document with particular objectives that appear in the Learning Space platform with the icon:  . The student is encouraged to dedicate a few minutes for reading and thinking about the goals established for each module. The particular objectives appear in *gold color*. Also, using *blue color*, the keys for the module activities and the average dedication times are shown. For instance, a typical module 1 objective is shown as follows:

MODULE 1: The operational amplifier, electronic conditioner for excellence.

PARTICULAR OBJECTIVES:

- **Perform analysis and design of electronic conditioning circuits using operational amplifiers**
- **Participate in solving operational amplifiers problems through collaborative work**
- **Propose electronic devices that include different sort of operational amplifiers**

KEYS TO ACTIVITIES: AE-01, EI-03,TP-01, AG-02, AE-02, EI-04, TP-02, AG-03, AE-03, EI-05, TP-03, AG-04, EF-01, EF-02, EF-03, EP-01, EPC-02, AG-05
TIME ESTIMATED FOR THE MODULE: 29 hours.

III. CONTENTS

The contents of the course are distributed in seven major groups:

G.1 The operational amplifier: electronic conditioner by excellence. (key letters AO).
G.2 The oscillator and signal generation circuits: control and synchronization signal generators (key letters CO).
G.3 The feedback circuits: to stretch bandwidth and linearity in analog signal amplification (key letters CR).
G.4 The converters DC-DC and the power operational amplifiers: energy converter devices. (key letters CAP).

G.5 The analog multipliers and phase lock loops, as the basis for communication circuits (key letters MCF).
G.6 The active filters: signal frequency selectors and processors for instrumentation and communication systems. (key letters FA).
G.7 The converters D-A, A-D, V-F and F-V: fundamental devices for the data acquisition systems (key letters CAD).

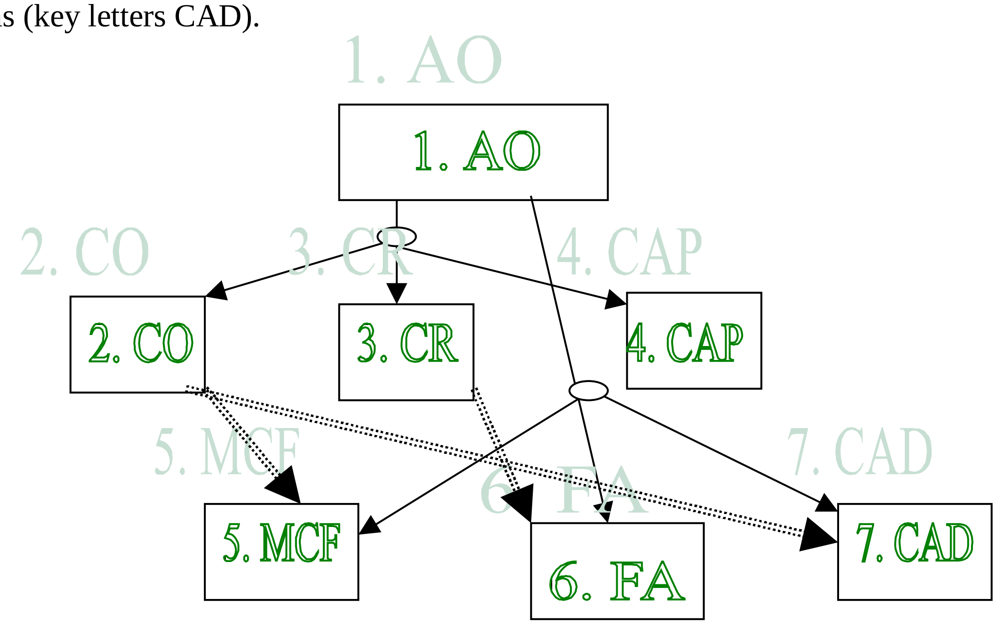

Figure 1: Diagram that shows the general content structure and their sequence [2]

Figure 1 shows a diagram that illustrate the content scheme, sequence and dependencies. The first content – or root content- appears as the basis for everything else. In the second level, the intermediate contents, (CO, CR and CAP) appear. They are the basis for the design of a wide variety of circuits that find direct applications on electronic systems. Finally, the third level is formed by contents (MCF, FA and CAD) that are very close to specific practical solutions to industrial electronic problems. This last level shows devices that are closer to reality and practical problems appearing day by day in modern electronic systems, particularly in instrumentation and communication systems.

The conceptual contents are:
1. Introduction to the analog integrated circuits course.
2. The operational amplifier, signal conditioning system for excellence.
2.1 Operational amplifier characteristics.
2.2 Operational amplifier configurations.
2.3 Circuits for linear conditioning.
2.4 Circuits for non-linear conditioning.
3. Oscillators and signal generators for control and synchronizing signal generation.
3.1 Sinewave oscillators
3.2 Timing circuits and clock signal generators.
4. Feedback circuits to stretch bandwidth and linearity in analog signal amplification.
4.1 Feedback effects
4.2 Feedback configurations.

4.3 Loading effects in feedback amplifiers.
5. DC to DC converters and power operational amplifiers, energy converter devices.
5.1 Voltage regulator devices.
5.2 Power amplifiers..
5.3 Isolation amplifiers.
6. Analog multiplier circuits and phase lock loops, basis for communication systems.
6.1 Two and four quadrant multipliers.
6.2 Phase lock loop circuits.
7. Active filters for selecting and processing signal frequencies in instrumentation and communication systems.
7.1 Low pass and high pass first order filter circuits.
7.2 Sallen-Key type low and high pass configurations.
7.3 Biquadratic filters.
7.4 Butterworth and Chebyshev filters.
7.5 Switched capacitor filters.
8. D-A, A-D, V-F and F-V converters, fundamental elements in data acquisition.
8.1 Weighted sum and R-2R lather D-A circuits.
8.2 Counting A-D converters.
8.3 Successive approximations A-D converters.
8.4 V-F, voltage to frequency, converters.
8.5 F-V, frequency to voltage, converters.

The procedural contents are:
P.1 Solve problems in analog electronics.
P.2 Collaborative work in solving homework and electronic projects.
P.3 Develop group projects.
P.4 Analysis and design of electronic circuits using approximations and using computer simulations.
P.5 Oral presentation of collaborative projects.
P.6 Written presentation of collaborative projects.
P.7 Written presentation of technical detailed reports.
P.8 Schematic capture and simulation of electronic devices.

The attitudinal contents are:
A.1 Recognize the impact of the course in the IEC professional.
A.2 Responsibility in knowledge acquisition.
A.3 Recognize the progress in knowledge acquisition, the collateral knowledge and the opportunities for improvement.
A.4 Recognize the achievements and the opportunity areas.
A.5 Recognize the impact to community.
A.6 Responsibility and honesty to evaluate the work performed.

IV. LEARNING STRATEGIES

To facilitate the teaching-learning process, a series of strategies or learning techniques are developed to have the student achieving a better and more adequate use of resources available for the course. This way he or she will take advantage of all the learning mechanisms to perform well in the contents mentioned above. The use of the technological platform such as "Learning Space®" [1,5] gives more flexibility and interaction through the following virtual spaces: ***Schedule***: Describes the activities, discussions, assignments, group work and projects showing the proper scheduling for the current semester; ***Media Center***: Illustrates learning resources that have been mounted by the instructors or their assistants. Those are available to the students for consulting, printing, and reading; ***Course Room:*** Virtual space designated to perform group discussions, collaborative work, virtual assessments or to turn in (if necessary) specific assignments; and ***Profile:*** Space to have the personal data of the students, assistants and instructors participating in the course. Table I shows a summary of the learning strategies used in the course.

Table I: Learning Strategies

Strategy	Place	Resources	External Group	Internal Group	Instructor
Interactive Lecture	Classroom	Textbook and references	N/A	N/A	Facilitator
Internal group activity	Classroom /Course room	Textbook and references	N/A	Yes	Coordinator
Weekly assignment of text problems	Optional	Textbook and references	Yes	N/A	Assessor
Monthly Project	Course Room	Virtual Lab., Concurrent engineering lab., Library, Internet, etc.	Yes	N/A	Assessor
Group Presentation	Classroom	Virtual Lab., Concurrent engineering lab., Library, Internet, etc.	Yes	N/A	Assessor
Weekly reading assignments		Textbook and references	Yes	N/A	Assessor
Personal or virtual assessment	Physical and virtual Office (Course Room)	Learning Space	Yes	Yes	Assessor
Questions for group discussion	Course Room	Learning Space	N/A	N/A	Assessor

The learning activities containing some of the above strategies are described in the document *"Programa del curos E-95-863: Circuitos Integrados Analógicos"* [2] that is mounted in the

Media-Center virtual space. To facilitate the reference to this document, a link to the *Media Center* document has been created from particular activities shown on the *Schedule*.

V. COURSE ACTIVITIES

The calendar of activities for the course is presented on a table format illustrated in the Media Center document called: ***"Programa del curso E-95-863: Circuitos Integrados Analógicos" (Course program for E-95-863: Analog Integrated Circuits) [2].*** Moreover, on the "Schedule" data base, the activities are ordered by modules and the students have access to them, either by calendar or by using the appearing module sequence. The activities are abbreviated with symbols or key letters to reference them easily. The different activity types are described as follows:

EI-XX: is an interactive lecturing by instructor and the students. XX is the number sequence.

AG-YY: is an internal group activity with number sequence YY. This type of activity starts in the classroom (at class hour) and it extends to an outside classroom activity.

TP-ZZ: is a textbook problem assignment with number sequence ZZ. This is an outside classroom activity that is completed in the classroom with a formative and summative evaluation by the instructor. Also the students fill out an self-evaluation form through Learning Space.

PM-0j: is the monthly project number 0j. This activity finishes with an oral presentation and a written report.

PG-0j: is the oral presentation for every monthly project.

To facilitate the project development the activity : **AGC-0j** is initiated where the client groups provide the design project proposal to the design groups for beginning the development process.

AE-ii: is a self-study activity that anticipates to an interactive lecturing: EI. Usually starts one week before the presentation and discussion of the material by the whole group.

EP-0k: is the monthly individual exam number 0k performed in the classroom (1 hour).

EPC-0k: is the monthly collaborative exam number 0k performed by external student groups outside the classroom (estimated working time 2 hours).

ExF: is the final individual exam performed in the classroom (1.5 hours).

ExFC: is the final collaborative exam performed outside the classroom (estimated working time 1.5 hours).

To facilitate the proper interpretation of the learning activities, a color code has been incorporated to the data base in the following way:

b. Title of activity [Red]
a. Professor/instructor and student activities [Blue]
c. Student activity [Blue]
d. Classroom activity [dark green]
e. Resources [light green]
f. Evaluation [Yellow]

For Instance:

==

AG-00: Introduction to analog integrated circuits. <red>

dates: [from January 20 to January 22]

Professor activity
***To coordinate and verify the formation of external learning groups. To distribute the diagnostic evaluation about previous background knowledge for the course.* <blue>**

Student activity
***To form external groups for developing the outside classroom activities (TP, PM and some AG types) during the semester. Use the form FGE-01 installed in the Media Center. To answer the questionnaire for diagnostic self evaluation about previous background knowledge.* <blue>**

Classroom activity: 0.5 hours, outside classroom: 1 hour. <dark green>
Media and resources: course program, self-evaluation questionnaire about background knowledge. <light green>

Evaluation: diagnostic. <yellow>
==

VI. COURSE RESOURCES AND BIBLIOGRPHY

The used resources for the course are:

a. Technological platform: Learning-Space running under Lotus-Notes.
b. Access to the WWW using the local network from ITESM or through modem via IntraTec.
c. Access to the virtual laboratory (LV) resources from the EE department at ITESM.
d. Access to the electronic concurrent engineering laboratory (LIEC) at the division of computing, information and communications (DCIC) from ITESM.
e. Textbook: N. Malik, Electronic Circuits, Prentice Hall, 1997 (English or Spanish version).
f. Reference text: G. Dieck Assad, Instrumentación-Acondicionamiento-Electrónico-y-Adquisición-de-Datos, Pre-edition 1999, ITESM (in process of publication by Prentice Hall Hispanoamericana).
g. Classroom with projector and terminal for access to the network.
h. Classroom with tables for classroom group work.
i. Classroom with flexible lecturing areas (blackboard, whiteboard, screen etc.).
a. Availability of one of the following electronic simulation programs: PSPICE, student version 6.0 and above, Spectrum Software, 1996; Electronic Workbench Pro, version 5.0 and above; Design Architect, schematic capture for Mentor Graphics concurrent engineering environment; Accusim II, analog electronic circuit simulator for Mentor Graphics.

The reference list for the course is the following [6,7,8,9,10,11,12]:
Textbook: Malik, N., *Electronic Circuits; Analisis, Simulation and Design*, Prentice Hall, 1995
Reference: Dieck Assad, G., *Instrumentación, Acondicionamiento Electrónico y Adquisición de Datos*, In process for publication in 1999 (Prentice Hall Hispanoamericana).
Other references are as follows: Sedra A.S., Smith K.C., *Microelectronic Circuits*, Saunders College Publishing, 3rd. edition, 1991; Savant S.J., Roden M.S., Carpenter G., *Electronic Design, Circuits and Systems*, 2nd. Edition, Benjamin Cummings Pub. Co. 1991; Wait, J.V., Huelsman L. P:, y Korn G.A:, *Introduction to Operational Amplifier, Theory and Applications*,

2nd. Edition, McGraw Hill Co, 1992; J. Millman, *Microelectronics*, McGraw Hill Books Co., 2nd. Edition, 1989; Schilling D., Belove C. *Electronics Circuits, Discrete and Integrated*, McGraw Hill Books Co. 3rd. Edition, 1989; Gray P., Meyer R., *Analog Integrated Circuits*, 3rd. Edition, John Wiley & Sons, 1994; Soclof S., *Design and Applications of Analog Integrated Circuits*, Prentice Hall, 1991.

VII. SYMBOLOGY

To facilitate the navigation through the data bases, the Table II shows the icons, symbols and key letters used to describe documents, activities and information appearing in "Learning Space®".

VIII. SOME FREQUENTLY ASKED QUESTIONS

What is a course redesign project?
Is the project of a course renewal to include wider aspects in the teaching learning process. In particular is a transformation of the traditional course model to include a more participative student and where the student is the focus of all the strategies, techniques and activities. The strengths of the traditional course model are preserved and the redesigned model will include in addition to the conceptual contents, the attitudinal and procedural curse contents. The professors and students need to be convinced that the change in attitude will achieve a much better higher engineering education.

What changes does a redesigned course include?
The fundamental changes in a redesigned course are primarily the roles that the instructor and students play. Here, the intentions, objectives, strategies and activities are centered in the student. Also the discipline will shape the changes to be included. The same learning model can not be applied to all the disciplines. Among the strategies that have made the course flourish are: group activities and collaborative learning, self study, special projects, question and discussion techniques, learning based upon problem solving, problems related to daily life situations, and visualization of impact of solutions to society.

What is expected from the instructor and from the students?
The professor must clarify intentions, objectives, contents, strategies and activities based upon an adequate justification. The professor lectures approximately 1 to 1.5 hours per week with strong interaction from students. Specifically the lectures are recommended in high difficult topics where the students might require more orientation and guidelines. The student is expected to be more participative at class lecturing. He must follow closely his personal progress, self-evaluation and co-evaluation. He must participate in group discussion through the technological platform and his contributions to assignments and class discussions must reflect his self-study activities.

What is the technological platform?
The technological platform is a computer program that facilitates the development of a redesigned course using administrative tools for instructor and students. The program uses a set of data bases that maintain documents pertaining the course and facilitates the group formation, team work, class discussion results, submission of simulation assignments, cooperative learning, project reporting, profile ID information posting, assessment processing and virtual office development. Moreover the platform offers a better way to organize the learning progress of the students keeping track of discussion assignments, simulation assignments and group working progress. Finally the platform permits the handling of multimedia materials or even connection

with electronic simulation through the network. This is available, even during class period to enhance the interactive lecturing by the instructor.

Table II: Symbols and key letters for the data bases

ICON/SYMBOL	KEY-LETTERS	VIRTUAL SPACE	DESCRIPTION
	AE	Schedule	Self-study
	EI	Schedule	Interactive lecture
	AG	Schedule	Group activity
	TP	Schedule	Problem assignment
	PM, PG or AGC	schedule, media center	Monthly project, oral presentation and project proposal
	EP and ExF	schedule, media center	Individual monthly and final final exam
	EPC and ExFC	schedule, media center	Collaborative monthly and final exam
	N/A	Schedule	Self-evaluation
	N/A	course room	Virtual office and discussions about self-study
	<Start Here>	schedule, media center	Course description and module objectives
	N/A	media center	References and bibliography
	N/A	media center	Summative evaluation scheme
	N/A	media center	Supporting material
	N/A	media center	Bridge to WWW
	module 0	Schedule	Group integration
	N/A	media center	Bridge to virtual lab.
	<Start Here>	schedule, media center	Course Introduction "module 0"
	N/A	media center	Exam solution

Do the conceptual contents for the course "analog integrated circuits" change?
The conceptual contents of the course are maintained in quantity and quality according to the original analytical program. A special emphasis is given to the connection between these contents and the real world. In this aspect the student is asked to focus his learning to procedures such as doing electronic capture and electronic design using the new methodologies of concurrent engineering. Additionally, the inclusion of attitudes, values and abilities proposed by the ITESM mission provides the fundamental thrust for this redesign effort.

IX. EVALUATION

The Table III shows the overall summative evaluation distributed among different course activities. It shows the impact of the self evaluations and co-evaluations for each activity. The last column illustrate the total percentile amount.

Table III: Summative evaluation for the analog integrated circuits course

Activities	Key letters	Instructor evaluation	Individual performance self-eval.	Collaborative performance self-eval.	Co-eval.	Summative evaluation
Self-studies	AE	0.5	N/A	N/A	N/A	7
Internal group	AG	0.8	0.1	0.1	N/A	8
Textbook problems	TP	0.7	0.15	0.15	N/A	8
Monthly projects	PM	3.0	0.5	0.5	N/A	12
Group oral presentations	PG	N/A	N/A	N/A	1.0	3
Individual exams	EP	7.0	N/A	N/A	N/A	21
Collaborative exams	EPC	2.0	0.33333	0.33333	N/A	8
Individual final exam	ExF	24.0	N/A	N/A	N/A	24
Collaborative final exam	ExFC	6.0	1.0	1.0	1.0	9
TOTALS		85	5.5	5.5	4	100

Table III shows that 85% of the total summative evaluation is responsibility of the instructor, 11% is responsibility of the individual student, and 4% is responsibility of students through evaluation of peers. Finally, the weight of the monthly exams is 21% and the final individual exam has a weight of 24%.

X. DISCUSSION AND RESULTS

A survey was applied to the students who took the course during the fall of 1997 in order to provide an insight into how they were impacted by the different activities of the course. An analysis of the 8 procedural and 5 attitudinal contents was made and the results shown on Table IV were obtained. For each activity (Left most column) the contents that according to at least 50% of the students influenced their working habits were posted on the table. For instance, on activity AG-01, 55% of the students said that the procedural content P-3 impacted strongly on their working habits, 75% of the students said that the procedural content P-6 impacted strongly on their working habits, 85% of the students said that the attitudinal content A1 impacted strongly on their working habits, 75% of the students said that the attitudinal content A-2 impacted strongly on their working habits and 85% of the students said that the attitudinal content A-4 impacted strongly on their working habits.

Table IV: Preliminary results of impact on the students taken the course (Fall 1997)

ID for activity	Percentage of students saying it had a major impact in their procedural habits								Percentage of students saying It had a major impact in attitudinal habits				
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	A-1	A-2	A-3	A-4	A-5
AG-01			55			75			85	75		85	
AG-02		70	65			80				75	70	65	
AG-03	80	70	60							75	60		
AG-04	95	80	50							90	80	65	
AG-06	79	89	95							84	83	79	
AG-07	100	100	95	100				100	80	85	75	80	75
AG-08	100	90	70						85	95	90		
AG-10	90	100			85			85	90	100		85	85
AG-11	90	100		100				95	85	90	85	85	
AG-12	100	94	60							100	89	88	
AG-14	88	82		94	88				100	100	76	100	100
AG-15, TP-09						84			79	79		84	89
EPC-01	89	89	68	95				89	58	79	73	58	
EPC-02		68	58			63			84	84		79	84
EPC-03		85	70			75			75	85		85	80
ExFC	95	95	95	100		95	95	100	90	95	90	90	90
PM-01	94	94	100			83			83	94	83	88	94
PM-02		100	100	85	100	90			90	85	75	85	90
PM-03		95	95	85	100	100			95	95	80	95	85
TP-01	80	50							50	90	70	50	
TP-02	80	50							50	90	70	50	
TP-03	90	80		80				70	85	90	75		
TP-04	90	80		80				70	85	90	75		
TP-05	100	80							80	100	80	85	
TP-06	100	79	53						79	100	79	84	
TP-07	100	79	53						79	100	79	84	
TP-08	100	79	53						79	100	79	84	

NOTE: The percentages above 50% were considered

Recalling the procedural contents shown on Table IV:

P.1 Solve problems in analog electronics.
P.2 Collaborative work in solving homework and electronic projects.
P.3 Develop group projects.
P.4 Analysis and design of electronic circuits using approximations and using computer simulations.
P.5 Oral presentation of collaborative projects.
P.6 Written presentation of collaborative projects.
P.7 Written presentation of technical detailed reports.
P.8 Schematic capture and simulation of electronic devices.

Also the attitudinal contents shown on Table IV:

A.1 Recognize the impact of the course in the IEC professional.
A.2 Responsibility in knowledge acquisition.
A.3 Recognize the progress in knowledge acquisition, the collateral knowledge and the opportunities for improvement.
A.4 Recognize the achievements and the opportunity areas.
A.5 Recognize the impact to community.

The attitudinal content A.6, responsibility and honesty to evaluate the work performed, was not surveyed in this initial effort because it was not originally included in the initial pilot group of Fall 1997. Some observations about Table IV are as follows. The procedural content P.7, is influenced strongly only by activity ExFC (Collaborative final exam). The attitudinal content A.2 is strongly influenced by all the activities. This table can be used for selecting particular activities to address specific contents or to produce cause-effect relations between activities and contents. In summary the Table IV shows that most of the activities have a significant impact on the student working habits, specifically all the ones regarding procedural and attitudinal contents.

XI. CONCLUSIONS

The implementation phase for the course was during the fall semester of 1997. Since then, one section was taught in the spring of 1998, two more sections in the Fall of 1998 and finally two more sections in the Spring of 1999. The course has had some improvements after receiving some feedback from students, professors and from the pedagogical associate. The implementation results after 1 year shows, on the students, a significant positive impact in 8 procedural and 5 attitudinal contents established in the Mission of ITESM. However, for the pilot groups of 17 (fall 1997) and 21 (spring 1998) students, the instructor has observed a significant increase in the teaching load compared to the traditional scheme. This might be due to the detailed personalized formative and summative evaluations for each student and the continuous verification of the virtual discussion occurring at "the course room". Additional refinements are developed in order to fit the scheme to the typical teaching loads required for the traditional courses at ITESM.

What changes have been made since the fall of 1997?

The course, so far, has been implanted during four semesters (counting Spring of 1999) with two different professors at the ITESM campus Monterrey. The conceptual contents are still the same and the program is covered adequately to prepare the students for the analog electronic laboratories.

During the initial three semesters of teaching under this scheme, however, several observations and feedback has been obtained from professors, instructors, peer reviewers, didactic assessors and technological assessors. The following changes have been made through these semesters:

1. Self evaluations are less complicated and easier to do through “Learning Space®”.
2. Formative evaluations have been increased in self-study (AE) and group activities (AG).
3. The co-evaluation among students have been implanted on the final collaborative exam (ExFC).
4. The Abbreviations for activities have improved to include not only key-letters but also descriptor icons.
5. The monthly projects have redesigned to give more time to designers group and also to include more relevant higher scale project developments. This include semester long projects with distribution in three monthly parts.
6. The average hours dedicated to the course has been revised to fit 128 semester hour dedication for a 3 credit undergraduate type course.
7. Support sessions to use the Accusim II simulator are provided to the students.
8. All the supporting materials posted on the Media Center have been revised.
9. There is much more logistic support for the Learning Space servers.
10. An introductory document for the course is now available at the <Start Here> section of the schedule data base. This orients and guides the student into the learning process.
11. A colorful code is implanted to provide more specific instructions about activities to perform by students and professors.
12. The reference book by G. Dieck Assad is included to make some of the topics more didactical for the students.
13. In Monthly projects the roles of the external groups are reduced to both, designers and clients.
14. Six group discussion activities about relevant topics of electronic technology applied to the community have been added into the Course Room.
15. A link to the virtual laboratory is created to have access to the Electronic Workbench simulator.
16. Each module now describes its own objectives via the very first document appearing in the module.
17. A Virtual Office is now at the “Course Room” in order to attend requests and assessments for the students outside the regular class or office hours.
18. A new versions of “Lotus Notes®” (4.6) and “Learning Space®” (2.5) were released and the course was transferred. The links were refined and the “***Schedule”*** was reviewed.
19. About 16 different custom designed front pages were created for the course. Each design contains a diagram related to the topic covered during the week and a message from the instructor is posted on each page.

Bibliography

1. ________, Distributed Learning: Approaches, Technologies and Solutions, White Paper, The Lotus Institute, August 1996.

2. Dieck-Assad G., Informe de Implantación del rediseño del curso E-95-863: Circuitos Integrados Analógicos, ITESM campus Monterrey, Julio 1998.
3. Martín-Pérez M., Rediseño de la Práctica Docente con base a la misión ITESM 2005, sistema ITESM, Junio de 1997.
4. Pérez-Rodríguez P. And Pérez-Rodríguez Y., ¿Cómo retroalimentar proyectos de rediseño de cursos? Sistema ITESM, CEA-Dirección de Desarrollo Académico, Monterrey, México, 1998.
5. Moreira, H., Hacia un nuevo modelo del proceso de enseñanza-aprendizaje basado en la misión del Tecnológico de Monterrey para el año 2005, sistema ITESM, Abril de 1998.
6. ________, Plataforma tecnológica Learning Space para el rediseño de cursos, Sistema ITESM, CEA-Dirección de desarrollo académico, Monterrey, N.L. México, 1998
7. Malik, N., *Electronic Circuits; Analisis, Simulation and Design*, Prentice Hall, 1995
8. Dieck Assad, G., *Instrumentación, Acondicionamiento Electrónico y Adquisición de Datos*, In revision for publication in 1999 (Prentice Hall Hispanoamericana).
9. Sedra A.S., y Smith K.C., *Microelectronic Circuits*, Saunders College Publishing, 3rd. edition, 1991
10. Wait, J.V., Huelsman L. P:, y Korn G.A:, *Introduction to Operational Amplifier, Theory and Applications*, 2nd. Edition, McGraw Hill Co, 1992.
11. Gray P., Meyer R., *Analog Integrated Circuits*, 3rd. Edition, John Wiley & Sons, 1994.
12. Soclof S., *Design and Applications of Analog Integrated Circuits*, Prentice Hall, 1991.

Graciano Dieck
He is currently the EE department head at ITESM campus Monterrey. He received his Engineering Degree in Electronics and Communications Engineering (IEC) from ITESM (1977). He received his MS and PhD degrees from the University of Texas at Austin, both in EE (1979 and 1983). He taught for 8 years at Trinity University. In 1994, he became EE chair, and since then he has been very active in optimizing undergraduate electrical engineering education. His research interests are: instrumentation and intelligent control, digital signal processing and electrical engineering education.

Artemio Aguilar
He is currently associate professor of Electrical Engineering at ITESM campus Monterrey. He received his Engineering (IEC) and Master Degrees from ITESM. He is associated with the EE department through the Center of Electronics and Telecommunications at ITESM. His teaching and research interests include: intelligent telephony systems, analog electronics, digital signal processing and microcontroller based design systems.

Sergio Malacón
He is currently associate professor of Electrical Engineering at ITESM campus Monterrey. He received his Engineering (IEC) and Master Degree from ITESM. He is very active with the redesign of the analog electronic sequence of courses at ITESM. He has been teaching using Learning Space® the Electronics I and II courses, which are taken by students before the analog integrated circuits class. His research interests include switching power supplies and data acquisition systems.

Manuel Macías
He is currently associate professor of Electrical Engineering at ITESM campus Monterrey. He received his Engineering degree (IEC) from ITESM. He holds a Doctorate of Engineering from University of Dresde in Germany. He is the coordinator of the virtual EE laboratory at ITESM campus Monterrey. He has been teaching analog electronics using Learning Space® for the past four semesters at ITESM campus Monterrey. His research interests include virtual instrumentation and power electronics.