# Leveraging the Educational Impact of the lLI Dollar: Ideas from a Microelectronics Processing Laboratory

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**Abstract**

Typical ILI projects involve incorporating a new set of experiments into an undergraduate lab. These experiments are usually centered around apiece of equipment that is implemented by the principal investigator. An alternative to this scenario is to use the implementation process as educational experience for the undergraduate students. This paper chronicles the implementation of an ILI project. Over 30 students were involved in the design and installation of the lab. The students' majors include Industrial Technology, Civil Engineering, Industrial Engineering, Mechanical Engineering, Materials Engineering, Welding Engineering Technology and Electrical Engineering. The lab is for Microelectronics Processing, but the ideas are generic and can be applied to implementing other projects.

## Introduction-The Case for Taking the Path of More Resistance

Engineering education in the 1990's has been undergoing many changes. Some of the changes, like using distance learning and interactive software learning tools, are fueled by technological advances[1,2,3]. Other changes, such as teaching students teamwork skills and cultural sensitivity, have been fueled by the nature of being an engineer in a globally competing marked. We are also faced with the challenge of how to meet these changing needs with fewer and fewer resources.

The Instrumentation Laboratory Improvement (ILI) program provides funds for enhancing undergraduate labs. The intent of the program is to support innovative laboratory education efforts. Although the ILI project will enhance the quality of education, the process of implementing the ILI project can provide valuable education opportunities. It requires more coordination of effort, but has valuable educational benefits. This paper describes how implementing one ILI project was used to give over 30 students hands-on education. We share our experiences in the hope that they will give ideas to other ILI principal investigators.

## Background - The Microelectronics Processing Lab

The ILI funding we received was actually the main portion of a larger project. The project was to construct an undergraduate lab to make integrated circuits. We proposed to use older technologies and alternative processing in order to minimize costs and chemical hazards. As shown in Figure 1, the ILI portion of the budget was almost 70% of the project's total budget. We obtained funds for the facilities by citing the ILI support.

In order to carryout the proposed ILI work, we needed to design and build a class 10,000 cleanroom with class 100 laminar flow benches, including electrical, gas, water and chemical safety systems. Cleanrooms that have a class 100 rating typically run about $500 per square foot for facilities alone. We built ours for approximate] y $25 per square foot, using a softwalled construction.

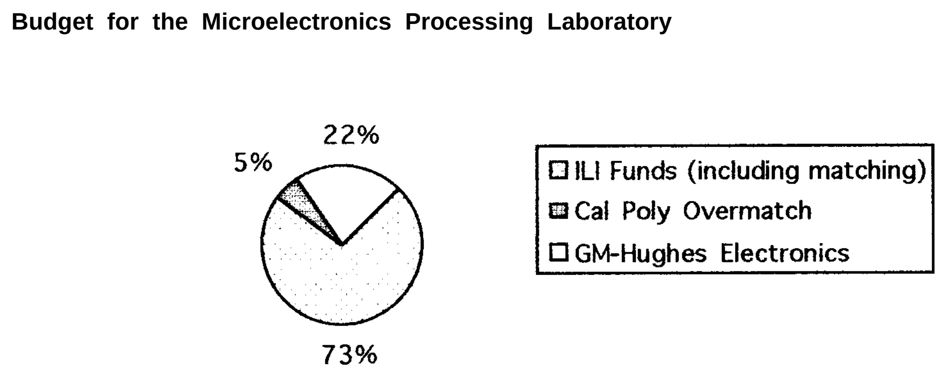


Figure 1. Budget for the Microelectronics Processing Lab. The ILI project was over two thirds of the total Microelectronics Processing Lab budget.

## The Implementation Process as Education

We decided early in the planning stages to allow students to be intimately involved with the design of the lab. Although it has made the project seem longer, it provided many learning opportunities. For example, in the initial lab design stages, a Materials Engineering student teamed with a Mechanical Engineering student to design the parameters for the heating, ventilation and air conditioning system. The Materials Engineering student needed to research the processes and materials used in integrated circuit fabrication (e.g. using photo-sensitive polymers) and the Mechanical Engineering student had to design an air handling system that could meet the needs.

Other projects gave teams and individual students a chance to contribute to the initial lab design. In deciding on the layout of the equipment, three teams of Industrial Engineering students submitted three different designs, based on the flow of materials, facilities limitations and space factors. A student in Industrial Technology used information on the lab's chemical needs to design a chemical hygiene plan in accordance with California law. Under the supervision of an electrician, a student designed the electrical system to meet the room's power needs.

Table 1 shows a summary of the projects that students were involved in. Keep in mind that these projects are not the main ILI project but projects generated from the ILI. At this point, over 30 students have had a chance to apply their knowledge by working on setting up the lab. We are also working with our Environmental Engineering Department to setup a miniature water treatment facility dedicated to the lab.

Table 1. Summary of Projects

| Project | #Students involved | Major of Students |
|---|---|---|
| Determiningg cleanroom environmental parameters | 1 | Materials Eng. |
| Designing heating, ventilation and air conditioning system | 1 | Mechanical Eng. |
| Building heating, ventilation and air conditioning system | 12 | Welding Tech. and Materials Eng. |
| Designing and building cleanroom frame construction | 3 | Welding Tech. and Materials Eng. |
| Designing and building power distribution system | 2 | Electrical Eng. and Civil Eng. |
| Designing and building exhaust system | 4 | Welding Tech., Materials Eng. and Electrical Eng. |
| Designing layout of equipment | 24 | Industrial Eng. |
| Designing and building gas distribution system | 2 | Materials Eng. |
| Creating chemical hygiene plan | 1 | Industrial Tech. |
| Designing and building laboratory vacuum system | 2 | Materials Eng. and Welding Tech. |
| Designing and building wafer spinner | 1 | Engineering Sci. |

Because there were no "right answers" in the design of the processing lab, students had the opportunity to work on open-ended projects. Industry experts agree that this is a much needed experience for the students[5]. The projects also required the people to interface with other students, developing their ability to work in a team situation - artother skill needed in today's engineers [5].

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## Developing the Lab--Unexpected Benefits of “Failure”

The first time the course was offered, we used a process for an integrated circuit based on p-channel metal-oxide-semiconductor field-effect-transistors. The mask set was designed and provided by Lynn Fuller of Rochester Institute of Technology. The course format followed that developed by Emily Allen and Evan Green from San Jose State University and described in these proceedings. Our lab acted as a test site for the portability of their open-ended design course.

We just completed our first offering of the course. As you might expect, things did not go as planned. For example, when we first applied photoresist (a light-sensitive polymer used in the process) to the top of the wafer, we somehow kept getting it on the back side of the wafers. The students solved this problem by redesigning the chuck that held the wafer so that the photoresist could not reach the back side[7].

Throughout the process we continued to encounter challenges, including problems with photoresist de-lamination, photoresist losing its photosensitivity, uneven coverage of spin-on glass dopants,...and more. However, each “failure” provided the students and me with an opportunity to practice our problem solving skills, applying our knowledge of the concepts.

## Summary

Receiving an ILI grant provides opportunities for educational experiences beyond the actual ILI project. Allowing the students to participate in the process of setting up the ILI project and solving the problems along the way builds team working skills as well as the experience of working on open-ended challenges.

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6. E. Allen, E.D.H. Green, L.S. Vanasupa, “Cooking Without Recipes: A Case Study for an Open-Ended Laboratory Experience in Semiconductor Processing, ” these proceedings.

7. For those who are interested in details on setting up your own Microelectronics Processing Lab, contact the author for *How to setup a dean room on a shoe string budget* and A *trouble-shooting guide for the first time processor (both* to be published in 1997).

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Linda Vanasupa joined the Materials Engineering Department at Cal Poly in January 1991 after finishing her M.S. and Ph.D. in Materials Science and Engineering at Stanford University. Her B.S. is in Metallurgical Engineering from Michigan Technological University (1985). She won the TRW Excellence in Teaching Award in 1992-93 and continues to further Cal Poly’s reputation as an educational institution.