

A Cross-Cultural VLSI Design Project

David Harris
Harvey Mudd College
Claremont, CA

Tayfun Akin
Middle East Technical University
Ankara, TURKEY

Abstract

Harvey Mudd College (HMC) and the Middle East Technical University (METU) have conducted a joint cross-cultural Very Large Scale Integration (VLSI) design course supported by a grant from the Mellon Foundation. In the spring of 2002, three teams of two American students HMC enrolled in E158 (Introduction to CMOS VLSI Design) worked with teams of two Turkish students from METU who had taken a VLSI course in the previous semester. The teams collaborated across cultures and time zones using email, web pages, chat, videoconferencing, and the telephone. At first students preferred voice communication to get to know each other; as the projects progressed, email and chat reduced difficulties with spoken English. Each team completed the design of a Mosis TinyChip. One of the designs, a FIR filter, was fabricated and tested to operate as intended. This paper describes the logistics of running the cross-cultural VLSI design project course. Students found that the extra communication effort roughly offset the time savings of splitting the project four ways instead of two. However, they enjoyed the experience working with colleagues from another country and of learning to manage a complex engineering task across multiple sites. They would have liked to travel and meet their counterparts, but insufficient funding was available. The project is being repeated in the spring of 2003.

Introduction

Engineering is a heavily team-based profession. Integrated circuit design has become so complex that the teams are very large and draw on geographically distributed specialists. For example, the Intel Itanium processor design team comprised approximately 500 engineers in California and Arizona collaborating with experts from Intel groups in Oregon and Israel and partnering with a Hewlett-Packard team from Colorado. Integrated circuit manufacturing is distributed around the globe.

Future engineers need to be comfortable working in design teams. Upper-division VLSI design electives are an ideal opportunity to develop these skills because team design projects mirror the realities of industry. Usually the design teams consist of students within a single class at a single institution. With the support of a grant from the Mellon Foundation for intercultural education with technology, Harvey Mudd College (Claremont, CA) and the Middle East Technical University (Ankara, Turkey) took collaboration one step further to experiment with cross-cultural VLSI design projects. HMC and METU are similar in that both offer outstanding undergraduate engineering programs and teach in English. However, they are eight time zones apart and are very different in culture and native language.

This paper describes the logistics and results of the cross-cultural VLSI design project as it was taught in Spring 2002. It briefly describes the overall structures of the course and the schedule of the student projects. The central objective of the grant was to develop experience in intercultural

education through technology, so we present the collaborative technologies explored. The results are assessed with student surveys. The technical aspects went well, but students would have liked to have learned more about their counterparts' culture. In the Spring of 2003, we are repeating the course with a planned Spring Break trip to Turkey.

Course Structure

The METU seniors in the project had completed EE413, a senior/Masters-level VLSI design course taught by Tayfun Akin in Fall 2001. Six of the students chose to continue with the design project in Spring 2002. Although the initial proposal called for granting credit, the METU bureaucracy could not approve credit in time and the students participated on a purely voluntary basis.

The HMC juniors and seniors were enrolled in E158 (Introduction to CMOS VLSI Design), taught by David Harris in Spring 2002. The class consisted of fifteen juniors and seniors. Most students were engineering majors, but one was from computer science and another from biology. More course information is available in [1]. The Spring 2003 class consisted of seventeen students.

E158 assignments begin with a series of five labs in which students built an 8-bit subset of a MIPS processor. Along the way, they learn to use the Electric CAD tool for schematic and layout entry, design rule checking (DRC), electrical rule checking (ERC), layout vs. schematic checking (LVS), simulation, and place-and-route. With this background they are prepared to propose and carry out a final project, working in teams of two. If teams fully verify their project and will be on campus in the fall for testing, they may fabricate their chips through MOSIS [2].

Five of the HMC students volunteered for the cross-cultural design experiment. The cross-cultural teams each consisted of two students from HMC and two from METU. One team had only a single HMC student because the class size was odd. The METU students also worked through the five labs to learn the CAD tools in preparation for the project.

Project

Each team proposed their own project. The three cross-cultural projects included an FIR filter (with a multiply-accumulate unit and input and coefficient registers), an adventure game based on a PLA generator written by the team, and a comparison of three 8-bit adders. Other projects included multipliers, ROM generator tools, and a hangman game.

Most HMC students are simultaneously enrolled in Engineering Clinic, a capstone design experience that consumes a great deal of time, especially in the final weeks of the semester. VLSI design projects are also notorious for consuming time. Therefore the VLSI project was heavily front-loaded to complete three weeks before the end of the semester. To keep the projects on schedule, students made written or oral reports at each of the following milestones.

2/25:	Preliminary Proposal
3/4:	Project Proposal
3/13:	Floorplan Complete
3/18-22:	<i>HMC Spring Break</i>
3/27:	Schematic Review
4/8:	Unit Layout Review

4/8-10: In class Design Review
4/17: Final Project Checkoff, Report Due
5/8: Project Presentations during HMC Presentations Days

All of the projects completed on schedule and met the original specifications. Some were more ambitious than others, but all demonstrated impressive effort. Three projects, including the FIR filter, were fabricated over the summer. All tested successfully.

Cross-Cultural Collaboration

The central challenge of the joint projects was learning to collaborate across language, cultural, and time zone barriers. The students had a number of communication technologies at their disposal:

- course web page with assignments and biographies and photos of each participant
- email
- Microsoft NetMeeting
 - chat
 - virtual whiteboarding
 - webcam with microphone for video conferencing
- prepaid phone cards

The following hardware was also available at HMC:

- scanner
- digital camera
- color laser printer
- color plotter

In addition, a pair of Mimeo systems was purchased for shared whiteboarding. These were tested at HMC and Pitzer College, which are on adjacent campuses. The systems were difficult to install. Once they were working, we found that it was not especially convenient to stand at a physical whiteboard while attempting to use video conferencing or chat; the virtual whiteboard in NetMeeting was more effective. The Mimeo eraser also did not work well over a network connection with latency between HMC and Pitzer. Therefore the Mimeo systems were returned.

Students at first tried video conferencing to negotiate project proposals and were attracted to the novelty. Some liked it better than chat at first because it gave confidence that the party on the other end was giving full attention to the conference rather than multitasking. However, the conferencing between continents was slow and of low quality. Voice was nearly unintelligible, though chat helped. Setting up a mutually convenient time to conference was also difficult. METU students found that HMC students spoke too fast and used too much idiom, while HMC students had difficulty with the Turkish accent. One team was proud of having been able to make a joke and have the other team understand the humor. The METU computer with the webcam crashed after a few weeks and there was no student interest in restoring it.

Students also tried prepaid phone cards because much industrial collaboration takes place over the phone. HMC students found the phone conversations to be of limited value because they had difficulty understanding the Turkish accent without associated body language.

In the end, chat and email proved to be the most important technologies to facilitate international communication for collaborative design. Email was also convenient, but lacked the immediate

turnaround helpful to hash out proposals and solve problems. In several cases, short delays in sending email caused full day delays in the work. Students would have liked a better mechanism for sharing files across sites without the lag associated with waiting for a collaborator to send email.

Assessment

HMC students performed a self-assessment of the experience in their final reports. The following statements are excerpted from the reports. Complete reports may be found on the class web page [3].

“Working across time zones and cultures was both an interesting and educational experience. Seeing how other teams approached design issues and how their thought processes differed from ours was valuable experience for future projects in the industry or academia. It was also interesting to learn about a different culture by interacting with people from that culture, instead of through the traditional abstract method of learning...Working with a team in Turkey was a very valuable experience, and we were very glad to have had the chance to do so.”

“Almost all communication with METU was done with e-mail or ICQ. I found this easier than talking on the phone with them because it was easier for me to understand and if there was some broken English I could take my time to understand it. I also didn't have to worry about understanding thick accents. All these things can make me sort of nervous on the phone, when it is a real time situation and you may have to ask them to repeat themselves, so phone and ICQ worked well for me...”

I found this experience very enjoyable and a good learning experience. This project would have gone incredibly more smoothly with the experience I have now. If I had gotten the whole hierarchical structure down earlier and was able to get that all straightened out in the beginning the project would have gone much more smoothly and we would have nicer looking layouts and schematics. I think it was a good experience and would recommend it to anyone who is looking for some experience for what working on projects in the real world may be like.”

“Although this author cannot speak for all the team members, the project seems to have been a success and the international cooperation was definitely both an asset and a chance to learn. Although the Mudd members of the team probably do not know very much more about Turkey, and the METU members probably do not know much more about the United States, all involved truly know more about what it means to work across borders and work with people on the other side of the world.”

Some of the written comments from METU students included:

I recommend them to prepare a timetable for meeting. Otherwise, it is difficult to find suitable time for all members. The other issue may be that before starting to draw the layout, they must agree on everything, such as the layout rules and the complete schematics. Otherwise they may need last day changes, which are not desired.

Actually this project was not intercultural enough because we have talked about technical details, schematics, layout rules, etc. There were too little times when we talked about ourselves. Time limitation due to the 8-hour difference can be one reason for that. Besides, this project was a part of HMC but not for METU. But, for sure this project was useful for my future career because I learned that no matter what the distance is between the partners teamwork can be achieved and the result was pretty good. I learned how to work people who I don't know anything about.

The main problem was the time difference between two countries. In order to connect by phone or netmeeting either they should stay at night or we should wake up at early morning. So connection with netmeeting was restricted. But the connection with netmeeting was more efficient as we can

discuss the project face to face. Hence the main connection type was with mail, but this was slower with respect to meeting.

This was a great experience for me because first of all I felt myself doing a project using all the available technological sources, secondly I felt myself important which increased my efficiency and motivation. Also meeting new people and thinking together was a good experience.

All of the students would have liked to meet their counterparts in person and would have enjoyed greater opportunities for cultural exchange as well as technical interaction.

Each participant was also surveyed about his or her experiences. The questions were scored on a scale of 1 (strongly disagree) to 4 (strongly agree). The other HMC students in the class who did not participate generally agree that the interactions of their classmates with METU enhanced everyone's learning and did not consume time that would better have been spent on course content.

Question	HMC Average	METU Average
The intercultural experience in this course enhanced my learning.	3.8	3.3
I feel I would have learned more from this course if more time had been spent on the course content instead of the intercultural project.	1.6	2
The intercultural experience in this course helped me to see course material from a different cultural perspective.	2	3.3
The intercultural experience in this course inspired me to consider traveling to other countries.	1.8	3.5
Independent of its connection to the course, I found the intercultural learning experience positive.	2.6	3.8
I feel that my interactions with students abroad gave them a better understanding of an American perspective.	2.6	3.5
Faculty should continue to incorporate an intercultural learning experience as part of this course.	3	4
The intercultural experience in this course helped me to become more aware of other cultural values and perspectives.	2.1	3.3
Doing this project helped me to learn more about my own cultural values and perspectives.	2	3
The intercultural experience assisted me in clarifying which career I will pursue.	1.6	3.3
The intercultural experience in this course made me more aware of my own biases and prejudices.	1.8	2.5
I will probably stay in contact with some of the students abroad after this course ends.	1.6	3

It is interesting to note that the METU students generally found the intercultural aspects of the project had greater impact. In both cases, there was widespread agreement that the experience was valuable and should be continued in the future. In private communications, METU students declared that they were impressed with the systematic thinking and the organized approach of the HMC students on problem solving, compared to METU students' approach of finding quick fix solutions to the problems. This shows that different cultures have different approaches in problem solving. METU students also thought that they knew more about the US culture than HMC students knew the Turkish culture.

Continuation

The project was sufficiently successful that it is being repeated at the time of this writing. Again, three teams of two students from each institution are participating. The HMC contingent will travel to Turkey for nine days over Spring Break to meet with their counterparts for technical and

cultural interchange. The American students will stay in the dorms with their Turkish hosts. The trip itinerary includes three half-day technical sessions in Ankara, trips to museums, mosques, and the Ankara castle, and unscheduled time for socializing. As no external funding has been located, students will each pay \$1500 to cover airfare and expenses. HMC is providing a limited amount of need-based financial aid. Unfortunately, airfare is prohibitively expensive in the current Turkish economy for METU students to make the reverse trip.

Some of the other changes planned include

- graded credit for METU students (desirable, but not implemented Spring 2003)
- better access to web conferencing hardware
- a shared email list
- formally scheduled meeting times

Conclusion

In summary, Harvey Mudd College and the Middle East Technical University have learned several lessons from this experiment in cross-cultural VLSI design. Videoconferencing is useful for socializing, initiating a project, and associating a face with a voice. However, students found that chat was the most effective tool for resolving design issues because written communication was clearer than oral communication and chat has faster response time than email. Although technology is now sufficient to allow technical collaboration across cultures and continents, students found it did not offer much insight into culture. This spring we will supplement technology with old-fashioned person-to-person contact.

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Biographic Information

DAVID HARRIS has been an Assistant Professor of Engineering at Harvey Mudd College since 1999. He received his Ph.D. in Electrical Engineering from Stanford University and his M.Eng. and S.B. degrees from the Massachusetts Institute of Technology. He is the author of *Logical Effort*, *Skew-Tolerant Circuit Design*, six patents, and assorted papers on high speed digital VLSI design.

TAYFUN AKIN is Associate Professor of Electrical Engineering at the Middle East Technical University. He received his Ph.D. in Electrical Engineering from the University of Michigan, Ann Arbor in 1994 and his B. S. degree from METU in 1987. His research interests focus on Micro-Electro-Mechanical Systems (MEMS) and silicon microsensors.