Evolving Education Paradigms, Friend or Foe?

William B. Hudson, Donald M. Gruenbacher
Kansas State University

Introduction

Not long ago successful instruction required only that an instructor be current with subject matter and present this material in a logical and cohesive manner. Many instructors went beyond the lecture and provided students with laboratories to reinforce key concepts. Recently the instructional landscape has begun to change. Some say these changes are in response to a changing student population, others believe that asynchronous instruction must be implemented to meet the changing needs of society and still others are of the opinion that classes need to focus on teaching the process of learning as much as the material to meet the ever expanding knowledge base. Regardless of the motivation many engineering courses are being "reworked" to utilize the ever increasing technologies brought about by the computer revolution. This paper presents the observations of two instructors that have implemented some of the new instructional tools and techniques in an introductory computer engineering course of approximately 100 students. No claim is made that this paper is a how to guide, rather, this paper is a collection of observations and concerns expressed by instructors and students associated with this course. The authors' intent in this document is to start closing the evaluation loop on what is appropriate and educationally sound use of technology in the classroom.

Course Background

EECE 241 is a required core course for Electrical and Computer Engineering students and a service course for other curricula. The presentation format has evolved to an integrated lecture and laboratory experience serving in excess of 100 students each semester. Previously the large number of students in this course was accommodated by using multiple faculty members instructing different course sections. This, while providing good faculty student interactions, resulted in heavy faculty teaching assignments and a student experience that differed depending on the instructor.

To reduce faculty teaching loads and to provide more consistency in material coverage the course was restructured to a large group lecture and a small group recitation environment (less than 14 students), with evening exams, and evening review sessions. The recitation meets each week for one hour and 50 minutes and lecture occurs twice a week in 50 minute blocks of time. The lecture is conducted by a faculty member while graduate and upper level students are tasked with recitation activities. The recitation activities are the same for each section and are coordinated with the lecture topics.

The stated goals for this course are:

1) allow reasonable faculty time commitment,

2) provide students with hands on experiences,
3) reinforce basic breadboarding and computer skills,
4) encourage active learning,
5) provide small group interaction,
6) encourage and reinforce time management skills,
7) identify as early as possible students having difficulty,
8) provide a consistent student product, and
9) begin developing characteristics of professional engineers.

EECE 241, An Introduction to Computer Engineering, is a course in which we strive to introduce current technologies while teaching basic underlying concepts. Because this is usually the first engineering course a student takes we also hope to excite students about the engineering profession.

Current Grading Criteria

Students in EECE 241 are evaluated using the following instruments:

4	One Hour Examinations
1	One Hour and Fifty Minute Final Examination
10	Collections of Course Notes
14	Recitations
1	Final Recitation Project
10	Electronic Homework Problems

Examinations

Examinations in this course take a very traditional written approach. All students take the examination at the same time. The exams require students to synthesize concepts and to analyze circuits. The examinations are graded in a traditional labor-intensive manner.

Course Notes

At random times during the semester student course notes for specific lectures were collected and graded. The notes were evaluated for accuracy, neatness, proper form, and completeness. This activity was to encourage students to document their activities. It is felt that good documentation skills will be required for a successful engineering career. To assist in developing the documentation skills the notes were required to be in the following form:

1) be contained in a binder with removable pages,
2) start with a new page for each lecture,
3) be consecutively numbered,
4) be dated,
5) contain the examples presented in class,
6) each page should be signed,
7) each page should have your name and section letter in the upper left hand corner,
8) key concepts and references clearly identified,

9) room should be left for you to add supplemental information during your review of the material.

The grading of the notes was accomplished in a very traditional manner with instructors quickly scanning the material to assign appropriate grades. This was found to be a very easy process. As might be expected there was very little middle ground. Student notes were generally found to be either very good or in need of much improvement.

Recitation

A major transition in this course has been to expand the "hands on" component to enhance student comprehension of basic concepts. We have found that many of our students have done no hands on experimentation, and, applied activities expand their skills and motivate them to remain in the program. The structure of the recitation has certainly evolved over the past few years. Initially, the recitation component was primarily made up of breadboarding exercises using small scale integration (SSI) and/or medium scale integration (MSI) logic and simple programmable logic devices such as the 16V8. Additional topics were added over time, and at one point a semester of recitation would include circuit design and breadboard construction using SSI and MSI logic, Altera CPLD design using both schematic capture and VHDL, PLD design using CUPL, and simple programming of microcontrollers. This was too much material in a semester so the VHDL and microcontroller components were dropped from the list of topics. The current recitation exercises consist of two weeks of SSI breadboarding, six weeks of design implementations on Altera CPLDs using schematic capture, and five weeks of CUPL based designs on PALCE22V10s. Each recitation exercise concentrates on designing, building, and testing an actual circuit. Approximately two-thirds of the exercises are devoted to combinational designs and one-third to sequential designs. The final 3 weeks of recitation are devoted to building a final project students keep after the semester is completed. A digital clock was the final project for the Fall 1998 semester.

Each recitation exercise includes design, construction, and testing. Because each recitation class meets for only two hours each week, meaningful design exercises can only be achieved if the design portion is completed prior to the actual recitation. Traditionally the distribution of recitation materials was done via paper form, but now the distribution is handled by the course web site. This allows students to access the recitation information remotely, but the preparation of materials for the web site does take considerable time for the instructors.

Both graduate and undergraduate students are used as recitation instructors, and each instructor is primarily responsible for grading the materials for their own class. The amount of grading is minimized with the use of electronic prelabs and check-off lists for the various completion points for each recitation. Students are not required to maintain a formal laboratory notebook, but the printed and written materials they produce through the semester may be bound together to form a record of their activities.

The use of a weekly recitation is intended to build the design and construction skills of the students over the semester. Since each recitation meets only for two hours each week it is important to maximize the use of this time by having the students come prepared for the

recitation activities. Students are encouraged to work through the recitation exercises prior to their recitation to ensure they understand the concepts and that they complete the activities. While Kansas State University generally attracts a large percentage of traditional students, we are finding more students who either have families or part-time jobs which do not allow them to come into the laboratory during normal business hours. It is difficult for these students to always adequately prepare for their recitation due to the limited lab access. Possible solutions to this problem could be electronic access and/or employed lab monitors.

Network Issues

Students in EECE 241 are required to use computers for various aspects of this course. Using network capabilities the students can obtain course material electronically as well as communicate with each other via the course list serve. The intent is to provide an asynchronous learning environment allowing each student to learn the material at a time which best fits their schedule. It also allows more time to be spent on exercises during recitation since the students are expected to understand the concepts prior to their recitation.

Because students are not required to own their own computers, the department provides a computing laboratory which they are encouraged to use. These computers are typically maintained by a system administrator in the department, and instructor access to account information and other network details is usually limited at best. At the beginning of the semester each student is provided a user id and password for an account on these computers. Students are encouraged to change their password to something they will remember, but usually one fifth of the class does not remember their password event though they were told to write it down. These students typically approach one of the instructors about their difficulties, who then informs a system administrator about the problem. It often takes between a couple hours and several days before the student regains access to the computers required for the course. With this occurring to over twenty people in the class, a large amount of instructor time and a delay in the student's access to required course materials precipitates.

Another difficulty arising from the computer network does not originate with the students but with the network itself. One common occurrence is the inability of a student to log into the network because the network failed to properly log the person off the network after the previous connection. Again the instructor has no power over this situation, and a system administrator must be found to remedy the problem. Other frequent problems include inability to forward email to other accounts and having no printing capabilities.

On the bright side, the network does provide a centralized location for students to store their files. This is definitely an improvement over the previous method of storing individual files on floppies, which was not a good situation due to both lengthened processing times (writing to floppies instead of the hard drive) and virus problems. However, when a student cannot log into the network they are also unable to get to the files needed for a recitation exercise.

Electronic Homework

Some previous versions of this course used traditional homework problems and student graders to provide feedback to the instructor. An electronic homework system has been used in recent years which allows for electronic submission and immediate grading through the use of the electronic forms on homework web pages. Although this system does eliminate the need for graders while providing immediate feedback to the students, there are several issues of concern.

The first is the amount of time required in designing an adequate number of homework problems that are suitable for use in an electronic grading system. Multiple choice and true/false questions are the easiest to implement. It is more difficult to implement a Karnaugh Map or logic design problem due to the restricted format the answers may be presented. In the Fall 1998 semester we were unable to produce enough homework problems to allow students to develop their design concepts in the appropriate time for the course.

Another commonly occurring problem was the use of an incorrect answer key without realizing it until a fair portion of the class had already submitted their homework. This would necessitate an instructor individually correcting the scores of students who had already submitted the homework, or requesting all students who had submitted the homework to resubmit once the correct key was in place. Either option was not pleasant, and the best solution of course is to have a correct key in the beginning.

Change is never easy. The effort required to implement a server and electronic homework has been extensive. Was the change worth it - without a doubt. Students feel good about the course, faculty time is saved, the students completing the course receive consistent material coverage. An unexpected side benefit is that changing of course material to keep up with technology has become easier. With one faculty member coordinating the course a desire to change or modify course content requires only a consensus of other involved faculty members and not a reeducation of all involved faculty members.

Course Web Pages

One of the most recent changes in the course is the use of a course web site for distribution of information. The web site includes the traditional syllabus information, as well as announcements, lecture slides, recitation activities, exam keys, online manuals and data sheets, and links to other sources of information. The intent of the web site was to reduce the amount of paper normally consumed for a class of this size. While all of the students did use the course web site, many thought that the site should contain ALL of the information required for the course. Making available a full set of lecture notes and other information was not the intent, as we felt that it was important for each student to develop his own set of notes. Unfortunately, many students found the web site to be a replacement for the text instead of a supplement. Some students also felt that it was necessary for the web information to be presented in the data format that they preferred for their own use. Having the same information presented in 10 different formats was not a practical or reasonable solution. Finally, the creation and maintenance of a web site proved to be very time consuming. A minimum of two hours each day could easily be spent updating information to keep everything current, and another two hours could be spent responding to student's suggestions and requests. This large time

commitment placed a burden on the achievement of the other tasks required to be completed by the instructors.

Electronic Presentation of Lecture Material

For one of the semesters we intended to produce PowerPoint slides of the lecture material. The students' response to this presentation format was to only copy the information presented on the slides. Very little, if any, synthesis of the information was observed. We also found a reluctance of students to record anything not shown on the slides. This we felt to be problematic in that many key issues developed as part of student questions were not recorded in their notebooks. This format seemed to encourage students not to read the book prior to attending lecture.

Closing the Loop

In order to evaluate student impressions regarding this course we actively solicited comments about the course. Below are a selected subset of student comments regarding the course as it was taught in the Fall 1998 semester. The students were asked to provide feedback about course format and issues of professionalism and ethics.

- First and foremost, there is no perfect solution to make this class better. I thought this class was great. Most of the things you guys did were good, but other people tell me that it's hard, the book should be incorporated more, we need weekly homework, and that you should lecture for fifty straight minutes instead of having group work. This may help some people learn more, but others may learn better from the present method.

- Should it be this easy? Since I've never been exposed to this stuff before, I wouldn't think so. I wouldn't go so slow next time. Speed up the timetable and teach more stuff. While the group work was okay, we do learn more when you put it on the board. (Note: The chalkboard is much better than the computer for presenting/teaching information. I think it 's too early for computers to take on that kind of role. Teachers may be ready for it, but it just seems too weird to me.) Also, try to find a book that can supplement your lectures. Maybe even have required reading assignments. In any case, following a book really helps out some students. Skipping around in a book makes it harder to learn and follow what's going on. Weekly homework assignment are especially needed to make sure students are practicing what you're teaching. Using the web was fine, but I wouldn't use it exclusively. Multiple choice isn't exactly the best way to do homework. If you can arrange it so the class meets three hours a week, a weekly 10 to 20 minute quiz might be in order. In the lab, I would try to make it more "real world" rather than "design this circuit." Since the final project was on CUPL, we definitely needed another week or two of experience on it.

- Homework is another important factor in being successful. Basically, if it's not done, you don't get credit, and if it's not done well, you shouldn't have wasted your time because your grade most likely won't be any better. A teacher once told me that "to teach is to learn twice," and I strongly believe this is true. "Helping," offers advantages for both parties. The teacher is enforcing what she already knows, while the student is learning, or understanding, for the first time. In this case, both benefit. "Copying," however, is another story. When someone puts forth only enough effort to plagiarize someone else's work, that is copying.

- The last concern that I had in regard to this class was the amount of work that was given at the end of the class. Most of the people enrolled in this class have other classes as well. At the end you gave a final project, final exam, and this paper, as well as a regular exam just two weeks before the final. That is a lot to get done at the end of the semester when you have other final exams and projects. Many of my other classes are suffering because I am spending so much time working on the things for this class. I think that you should give a final project or a final exam, but not both.

- I did my best to make it to every class (I missed one or two throughout the semester) and paid very close attention. I have a grip about the note taking policy you have because in my past, I discovered that I really understand the material better if I stop taking notes and focus on what the teacher is saying. Par for the course, however, the students that complain the most are the ones that come to class the least.

- As a computer science major and not a computer engineer, some practices in the class seemed a bit foreign to me. I found people worked together much less in this class than the students do in my CS classes. I find it difficult to believe that computer engineering is much less group oriented than computer science. We are encouraged to work together and share each other's code, but refrain from directly copying it. Simply looking at a classmate's code doesn't constitute copying, but it helps the student understand how the project is supposed to be done.

- Surprisingly enough, there was an underlying theme in most of these topics – people taking responsibility for their actions. In the public schooling system, we students have been spoon-fed and hand-held for so long, it is a rough transition when those ties are finally severed. People try to lean back on these supports, but when they are not there, end up weaseling their way around the real point at hand. Somehow along the way, there must be a way to teach students to become more confident at working independently, at criticizing one's own work, and for seeking help when help is required. And most of all, for when something goes wrong, this weaseling must end. Eventually, everyone must be able to stand up and say it was I who was wrong at some point in his or her life.

- EECE 241 Intro to Computer Engineering is a beginner's level course and this is exactly how it should be treated. The students come from backgrounds of an

extensive computer background to students who had no computers in their high schools and have just learned how to e-mail within the year. This course for the most part worked more towards scaring students from a possible future in Computer Engineering by making too many assumptions to the background of the students. To help avoid this a preliminary test to find one's level of understanding may be in order and base the recitation classes on these tests. Put the less advanced students at the end of the week so they have more time to learn the material, and the experienced students at the beginning of the week since they will need less time to prepare, thus hopefully providing a better distribution of grades throughout the week.

- Overall, this class has proven to be a great learning experience for me and hopefully anyone else who enrolled in it. I found the electronic submission of homework to be very unique and simple. The idea demands responsibility to check the web site daily for updates and new assignments, and I think that it is important to the learning process. One important item that could be added to the syllabus is a list of available places, people and references from which any student could get adequate help when needed. Students must know that the help is out there and that no one wants them to drop the course because they do not feel they understand the material. Also, labs should be addressed in lecture more often so everyone can understand what he or she is going to be doing during the recitation time. Regardless of these minor flaws in the course this semester, Dr. Hudson and Dr. Gruenbacher deserve much respect and appreciation for their efforts to maintain and constantly improve the course. It is a pity that not many other teachers do the same.

- When I walked into Paslay Lecture Hall for my first EECE 241 class I was 20 minutes late. These two guys up front were talking at 1000 mph about stuff I have never even heard about before, and I was trying to read Power Point slides from 50 rows up. My first reaction was, "This class is going to suck!" You will be happy to know that my opinion has changed. I would definitely say that this has been a wonderful class in which I have learned a ton. Nevertheless, even with how much my opinion has changed, there are still some aspects of the class that require improvement.

- In conclusion, I thought that EECE 241 was an excellent class. I learned many new concepts and ideas, as well as gained great problem solving experience through recitation. One complaint that I do have is that the textbook is almost worthless with this class. Surely there is a book out there that is written in a manner more easily understood. I like the tests in this class. Concept testing is great. The exams made me think, but had enough give-me's to be fair. I do think that there needs to be more homework assigned. Telling students to make their own practice problems when they aren't familiar with something does not work very well. I with that every class graded their tests as quickly as they were graded in this class.

- What I would like to see more of in EECE 241 are the following key points:

1. More homework.
   More homework with answers helps students focus on central ideas. The homework would not need to be graded; having the answers would be enough. A solved problem or two scanned onto the Internet might take you 15 minutes, but it might save students hours.
2. More detailed lab assignments.
   I spent more time trying to understand what was being asked of me that I spent understanding the concepts on the labs.
3. More positive habit forming.
   Signing and numbering notes is a good idea. It is something that I never would have done myself. I have found my past employers impressed with engineers who are organized and take credit for what they did.

- In today's society, the idea of professionalism is not something young people learn at home, much less in the public school system. Therefore, it is incumbent upon those who initiate individuals into the field of engineering to also initiate them into the practice of professionalism. Specifically, this responsibility falls upon the professors and faculty of higher learning institutions. One professor said to students in an *Introduction to Electrical Engineering* course, "If you are unwilling or unable to uphold the values, tradition, and professionalism of this chosen field, then I do not wish to have you as a fellow engineer." Such pride, commitment, and dedication are indicative of professional engineers.

- It is imperative that all persons entering the field of engineering know what expectations exist regarding professionalism. How are future engineers going to learn professionalism unless someone teaches them? Every professor and faculty member who instructs in the field of engineering should hold their students to a higher standard than before in order to properly prepare them for the future.

- Although web-based homework is a great idea, the way that it is implemented in this course is poor. Students do not benefit from it due to the fact that it is too simple. Homework should be indicative of material likely to be on exams. The web-based homework tends to be trivial, and of no educational value. The homework must be challenging, whether it is web-based or not.

Issues We Are Struggling With

- The Altera software was selected because of the licensing agreement which allowed students to install it on their personal machines. This, however, has created an uneven playing field for students without computers.
- We do not believe the electronic homework yet challenges and reinforces necessary concepts. The multiple-choice format does not lend itself well to design synthesis and creativity.
- Is it appropriate to force students into note taking if they already have a grasp of the concepts presented, or if they learn better through active class discussions?

- How do we verify who is doing the work with electronic submission of homework assignments?
- Does the use of structured PowerPoint notes prevent students from developing the skill of concept identification and synthesis, *i.e.*, information filtering?

Conclusions

The workload on faculty to change this course to the current format has been extensive. Reliance on technology has removed from faculty control and requires the support of many other individuals to be successfully implemented. Student responses to the changes have been generally positive, and skills gained by students have been greater as compared to previous course structures. The student population has changed over the years. Very few of our recent students have had any hands-on experiences with actual electrical circuits. This past semester we found that less than ten percent of our students knew how a flashlight worked. We believe the student body and technology will continue to change, requiring us to constantly refine course content and material.

WILLIAM HUDSON
William B. Hudson received the Ph.D. degree in Electrical Engineering from New Mexico State University, Las Cruces, New Mexico, in 1990. He is currently an Associate Professor in the Electrical and Computer Engineering Department at Kansas State University with teaching responsibilities in the areas of neural networks, fuzzy logic, digital design and digital microelectronics. In addition to his teaching responsibilities Dr. Hudson has served as the IEEE student branch counselor and the Kansas City IEEE Computer Society Chairman. Dr. Hudson's research interests include synthetic speech production, neural networks, robotics, and adaptive technologies.

DONALD GRUENBACHER
Donald M. Gruenbacher is an Assistant Professor of Electrical and Computer Engineering at Kansas State University. Dr. Gruenbacher received a B.S., M.S., and Ph.D. degrees in Electrical Engineering from Kansas State University in 1989, 1991, and 1994, respectively. His research interests include communications, hardware description languages, and educational methodologies.