Abstract — Teaching Freshman students, particularly in engineering, has and continues to be the subject of numerous papers. This paper describes another approach to introduce Freshman students to Electrical Engineering (EE). This is done through the Freshman course - ELEG 1003: Introduction to EE - which has been taught since Fall 1995 in the Department of Electrical Engineering of the University of Arkansas at Fayetteville. The main goals of this course are: (1) teaching problem-solving skills, (2) teaching the required knowledge in complex numbers and matrix operations, (3) introducing PSpice and Matlab**, (4) starting to develop communication skills, (5) engaging our Freshmen in group work, (6) illustrating the different areas of EE, (7) increasing our Freshman motivations for a career in EE, (8) imparting to the Freshmen a sense of belonging to the Department, and finally (9) improving our retention rates (if possible). The paper addresses how these ambitious goals are accomplished throughout this one-semester Freshman course.

I. Introduction

In the 1950’s the College of Engineering at the University of Arkansas taught a course for all engineering Freshmen. The students thought that the main purpose of the course was to teach slide rule operation with some algebra and trigonometry included for good measure. But the real purpose was to teach problem solving skills. Many professors thought this to be the most valuable course in the curriculum. They saw the difference in the test papers between students who had taken that course and those that transferred in after their Freshman year, and were therefore exempted from taking it. Unfortunately the hand-held calculator replaced the trusty slide rule and the instructor in charge moved away, so this course was dropped from the curriculum.

Now we face a different set of circumstances: namely, (a) Some Freshman students do not have the background required for entrance into the Engineering curriculum. Not all high schools place the necessary emphasis to pursue a career in engineering when it comes to topics as complex numbers, problem solving skills, and computer literacy. This places some Freshman students at a great disadvantage; therefore, it has become necessary to make sure that all Freshmen have the required background to pursue a career in Electrical Engineering (EE). (b) PSpice and Matlab are used regularly in upper level EE courses. Before this new Freshman course, the students learned these computer programs on the fly and basically on their own, i.e., as they first used them in the course. Also, some students never acquired a good command of these two packages. This “just in time” self-learning may be the way to go, but it seemed to us that previous exposure in these topics would reduce “frustration” in the more advanced courses. (c) Also, there is the sense of belonging. Before implementing this new Freshman course, the first EE course for most Freshmen occurred in the first semester of the Sophomore year. There was no sense of belonging for Freshmen, especially during the transition from the high school to university life. (d) Finally, many students did not have a clear idea about the different areas/disciplines of EE or the daily activities of an engineer; having a better idea about EE should motivate further our students.

The purpose of the course, and the reason we spend considerable faculty time and resources on the course, is to provide the necessary background in (1) problem-solving skills, (2) complex numbers and matrix operations, (3) PSpice and Matlab, (4) communication skills (written reports and PowerPoint presentations), and (5) group work, which includes a class project. We also wish to (6) illustrate the different areas of EE so our Freshmen can make a better selection of their EE disciplines, (7) motivate our Freshmen better for a career in EE, (8) impart to the Freshmen a sense of belonging to the Department, and finally (9) attempt to improve our retention rates (if this is a possible task).
II. Course Content

The course content includes problem solving skills, communication skills, complex number arithmetic, matrix algebra, PSpice and Matlab, a class project that requires soldering, student presentations covering many of these topics, and several presentations by practicing engineers. Students organize themselves in groups. We try to limit the group size as much as possible, depending on class size. In our experience a group size of 2 or 3 seems ideal since some group members do not participate as much as they should in larger groups. This group concept also teaches cooperation and resource management since the groups work more efficiently whenever the work is divided according to skill. We allow group members to be “fired” and allow transfers between groups. This puts some pressure on students to perform well and do their share of work. Of course, some Freshmen do not come to class and do not hand in their homework; but there is not much one can do when this happens.

Problem Solving Skills

The term problem solving means different things to different people. To some it means brainstorming and innovative thinking. To others it means a systematic and structured approach designed to enhance logical thought. This is the approach needed by most engineers in practice, and is the connotation used in our course. We use a three step procedure, (1) State what is given, (2) State what is to be found, and (3) Break the problem into parts, solve each part independently, and then combine the solutions to obtain an answer to Step (2). We spend approximately three 50-minute lectures explaining this three-step procedure while the students put in practice the approach when solving different homework assignments throughout the semester. Although accuracy of their solutions is important, the grading places emphasis on whether the students follow the above approach or not.

Complex Numbers and Matrix Operations

We spend approximately two lectures reviewing complex numbers and two lectures reviewing matrix operations. In addition, the text by Etter [2] allows us to use these concepts in a variety of applications later in the course. This further strengthens the student’s background in these areas that are so vital to later courses.

Matlab

Our upper level courses use Matlab extensively. Therefore an early introduction to the power of Matlab serves our students well. We attempt to motivate our students by requiring that they present Matlab homework solutions to the class. We are able to introduce complex numbers, linear algebra, system theory, and graphics by using Matlab [2]. For example, we use the conv(x,y) function in Matlab to multiply two polynomials. As a side issue we also show how this same function finds the output of a linear system (a shift register or delay line) and explain convolution in simple terms.

Freshmen learn how to plot the complex exponential function (a rotating phasor) in three dimensions, as well as other functions, how to multiply matrices, and how to generate random functions. We also study interpolation and curve fitting, regression, numerical integration, and numerical differentiation. This Matlab instruction takes approximately fifteen lectures.

Communication Skills

We attempt to teach both verbal and written communication skills by asking each group to make presentations and/or submit written reports throughout the semester. By sharing the group load everybody gets into the act without undue stress. Furthermore these groups are necessary for a large class, for otherwise we would not have the time for classroom presentations.

We teach the use of Microsoft PowerPoint for presentations, and this seems to fire students’ enthusiasm.
This active participation of presenting the solution of homework problems in PowerPoint also motivates the learning of problem solving skills and the use of PSpice and Matlab. They seem more than eager to make presentations once they learn that PowerPoint makes it easy.

For their written reports we stress three points. (1) Use the active voice when possible, without using personal pronouns, (2) provide detail, and (3) be specific. Many Engineers write to put their audience to sleep, because some English teacher told them that technical writing should use the passive voice. They also admonish students to keep their sentences short and to the point, but students interpret this to mean that they should skimp on detail. We try to head off or correct these false impressions by stressing the above three fundamentals of good writing.

The Class Project

For the group (or class) project they are free to choose from two kits [3]; namely, a sound-controlled robot and a telephone. We provide an open lab staffed by Teaching Assistants to help them learn good soldering techniques, but otherwise they are on their own. Most purchase a small soldering iron and complete the kits in their room. We supply one kit per student (i.e., a group of 3 students will get 3 identical kits), but they usually construct them as a group. They often ruin the first kit, do better on the second kit, and produce a working model on the third try. In addition to acquiring good soldering skills the students obtain time management (i.e., scheduling) and trouble shooting skills as well as a sense of accomplishment. Also, they learn the basic functions of electric components (e.g., resistors, diodes, transistors, electric motors) and systems (e.g., motor drive, control circuitry, telephones, robots, etc.) which is an excellent introduction to our Circuits I course. By the time they complete their kits near the end of the semester they are old pros at making presentations and writing acceptable reports. Thus the presentations of their soldering experience is the highlight of the course, and the class usually enjoys the “funny” soldering stories. Finally, the students in our first offering also had the choice of dc supply, multimeter and AM radio kits. We then realized that these kits were not very suitable for our Freshmen so now we offer them the choice of the above two kits.

The Areas of EE

We also attempt to motivate our students further by bringing in outside speakers from nearby industries covering most EE areas, by asking some of our senior students to share their “learning curve” with them, and by conducting plant tours if possible (e.g., the Southwestern Bell Telephone switching facility or the Baldwin Electronics Company). At this point it must be mentioned that it is difficult to get the whole class to attend a plant tour because of time constraints; that is, some Freshmen have other classes scheduled so they cannot participate. Additionally, we are now encouraging our Freshmen to join the IEEE Student Branch on their plant tours. Also, we use this course to illustrate the EE curriculum with particular emphasis on the technical electives as they relate to the different EE disciplines.

A Sense of Belonging

In addition to the sense of belonging provided by the course, the Student Branch of the IEEE and the EE Honor Society Eta Kappa Nu organize a “pizza” party where Freshmen are introduced to the Faculty members and the officers of these two student organizations. This pizza party is open to all students in the department. The fact that Freshmen make now frequent use of the EE Study Center is a good indication that they feel included in the department.

Retention Rates

At the writing of this paper, we do not have any concrete statistical evidence that this course might be improving our retention rates since the course has been offered only 4 times. Most of the EE Freshmen leaving our program in the last five years have transferred to the College of Arts and Sciences. Perhaps, the main reason was that they did not like engineering, but they viewed technology as glamorous and financially rewarding. Therefore, a freshman course will be able to do little for these students.

III. Student Experience

Freshmen generally receive this new course well. They realize the positive benefits to be gained in the future from their knowledge of problem solving skills, complex numbers, PSpice, Matlab, communication skills and the different areas of EE. Also, some of them are pleased to gain soldering skills, especially those with no previous experience. Some of them have problems with (a) understanding PSpice and Matlab without having had a course in Circuits, Electronics or Programming, and (b) working in groups. We try to convey that we are only teaching the “mechanics” of these 2 programs, the electrical concepts will be seen in future courses but some Freshmen still want to know more about electric circuits. Regarding the group members, we try to emphasize that similar situations will arise in a working environment where team members do not contribute their fair share and they need to learn how to handle these situations.
Finally, teaching PSpice and Matlab to Freshmen is not a trivial task. Hence, we made changes to the course material sequence as we were getting feedback from the students during the first 2 offerings of the course. Although this looked unorganized at times, it helped us to present the material in a coherent manner. Now, the course material sequence has a well defined structure.

IV. Conclusions

We instigated ELEG 1003 - Introduction to Electrical Engineering to help Freshmen learn problem solving skills, PSpice, Matlab, and to impart communication skills. These topics have been covered before in the other Freshman courses (proposed at other universities); however, we have not seen all of them combined into a single Freshman course. Although it is early, the positive aspects of this multi-purpose course are appearing in the attitude of our Sophomores and in the comments of their instructors.

Having to present their solutions to the class in PowerPoint provides practice in communication and motivates the use of PSpice and Matlab. They can copy Matlab graphs into PowerPoint for display to the audience. Many of these Freshmen have a sophisticated knowledge of computers, and they can be very innovative in their presentations. The Instructors learn as much as the students about the software during some presentations.

The students construct either a sound controlled robot or a telephone for a class project. This provides familiarity with electrical components and systems as well as soldering, along with the trials and tribulations of group work (e.g., to be patient). The presentations of their project are the highlight of the course. So far we are pleased with the course and its effect on our Freshmen.

References

