Retention of the Engineering Bound Student
A Problematic Approach

Wayne J. Zimmermann

Department of Mathematics & Computer Science
Texas Woman's University

Abstract

In this paper a brief outline of how a number of courses in the Department of Mathematics and Computer Science at TWU are being modified to assist in the migration of some of its students towards an engineering degree.

Introduction

Recruitment and retention are temporal and though they must be addressed continually, the intensity will vary with time. Both are aimed at solving two problems: university enrollment levels and supplying society with trained professionals. For many, if not all, the activities of recruitment and retention are as important as the teaching. For the Department of Mathematics and Computer Science at Texas Woman's University target of recruitment will be broaden. Also the course offerings will be broadened to assist in the task of retention and training. These modifications are the result of our partnership with the Electrical Engineering Department at Texas Tech University (TTU).

This partnership between TWU and TTU differs greatly from earlier collaborations TWU has had with other universities, specifically the University of Texas at Dallas and Texas A&M. In these early reciprocating activities the idea was that each school award a baccalaureate degree to the student at the completion of a five-year plan, three years at TWU and two calendar years at the cooperative university. Under such a plan the student would have degree in mathematics from TWU and a degree in engineering from the selected university. To quote the TWU 2003-2005 catalog,

> "The dual degree program in mathematics and engineering combines the strengths of Texas Woman's University and the University of Texas at Dallas (UTD) or Texas A&M University at College Station (TAMU) to enable our

> students to earn two degrees simultaneously while preparing for a professional career in engineering.
>
> Undergraduate students attend TWU for three years as mathematics majors in the Department of Mathematics and Computer Science, then continue their education at the Erik Jonsson School of Engineering and Computer Science at UTD or the Dwight Look School of Engineering at TAMU for two additional years. After completion of the degree, students will receive the Bachelor of Science degree in mathematics from TWU and the Bachelor of science degree in engineering from either UTD or TAMU."

As indicated the Department of Mathematics and Computer Science at TWU has recently formed an alliance with the Department of Electrical Engineering at TTU. The alliance is coupled tightly to the graduate recruitment efforts of TTU. As one of several a supporting institutes TWU is to assist in directing potential engineering students to do graduate work in the Department of Electrical Engineering at TTU. We at TWU viewed this alliance as an opportunity to improve our recruitment efforts by broadening our efforts. Once committed to this aspect TWU is then committed to providing basic concepts in science and mathematics that are essential to the program created by TTU. In summary TWU must recruit, retain, and train these potential students.

Retention.

Like recruitment there are a number of factors that impact retention and many of these factors are the same factors affecting recruitment. For example the economic state has a direct impact on recruitment and it also has a direct impact on retention. But for this article we will restrict our discussion to the topic one topic, namely course offerings that influence the level of knowledge the target population is brought to.

1.	National economics
2.	Perception of the university
3.	Placement service
4.	Course offering
5.	Faculty
6.	Laboratory
7.	Financial assistance
8.	Student's desires
9.	Social climate

Table 1. Factors impacting retention.

Factor 4—Course offerings:

The Department of Mathematics and Computer Science has taken the position implied by this factor. Based on the belief that by offering the appropriate courses retention would be improved we began the process of creating a small collection of courses designed to teach and illustrate the elementary concepts and viewpoints related to engineering. For TWU this approach seemed to be the best and most feasible for addressing the issues linked to retention. Since we are a mathematics/computer science department these courses need to include the basic principles of mathematics, physics, and chemistry that are common to the foundations of engineering. This can be done in the abstract the student must see some elementary engineering examples. Our approach in redesigning these courses is based on the assumption that the student learns more when the student does more. Thus the courses must contain elements that provide the student with a-hands-on problem solving. So are these new courses, or are they existing courses modified to do the job? We have elected to modify four of its courses. These courses would serve as platform for the dissemination of the selected information. There is a fifth course designed to disseminate those topics not incorporated in the four courses.

The five courses we have elected to modify are:

1. *Digital logic,*
2. *Assembly language,*
3. *Computer architecture,*
4. *Differential equations,*
5. *Topics in Electricity & Magnetism and Circuits*

They will be required or recommended to potential engineering students. The first four are existing courses while the fifth is a ‘new’ course. Major modification is being done to the first three. The course on Differential Equations is simply refocused. It now contains more applications with many of the examples and problems coming from physics, chemistry, engineering and electrical engineering. The last course is simply a course to familiarize the student with notation and tools used in electrical engineering.

Having selected these courses as an instrument for the retention and training of potential engineering students we were faced with the problem of how they should be modified. Initially the process began with the embedding each course with a practical engineering problem, more of a case study. Generally the problems are too complex given the time constraints of the classroom and the need to retain of the initial purpose of the course. But we wanted the approach to be more than simply that of inserting typical engineering problems and going over these problems. Hence we felt that the student should learn these problems in a manner similar to the Harvard MBA program. Thus each problem is presented as a case study. The student is required to read case then formulate a concise problem. Once the problem is formulated the student is then required to draft at least two possible solutions, which they are to present to the class. They then write a complete proposal and finally implement the prototype when feasible. If prototyping the complete design is infeasible, and that is generally the case, then a component of the project is identified for prototyping.

Course 1. Digital Logic & Design.

For the past several years this course has used the text “Digital Design” by Wakerly. The topics typically include: Introduction, Number Systems, Digital Circuits, Combinational Logic Design Principles, Sequential Logic Design, and Memory. Currently the material is presented with a little more of the basic principles from electrical engineering embedded into the syllabus. Care must been taken keep in mind that course was designed for the computer science major. There are two projects included in this course and they are easily completed.

1. Design the control unit of a traffic light that will be installed in an intersection. The traffic flow, and other specifications are given in a handout. The handout out is a bid for the construction of the controller.

   A diagram of the intersection is given in Figure 1. The timing of the various states is varies. This gives me the opportunity to ask why it would very. At least one of the states must include a left turn signal. Needed information for the controller can be found in J. F. Wakerly's text Digital Design Principles and Practices, [1].

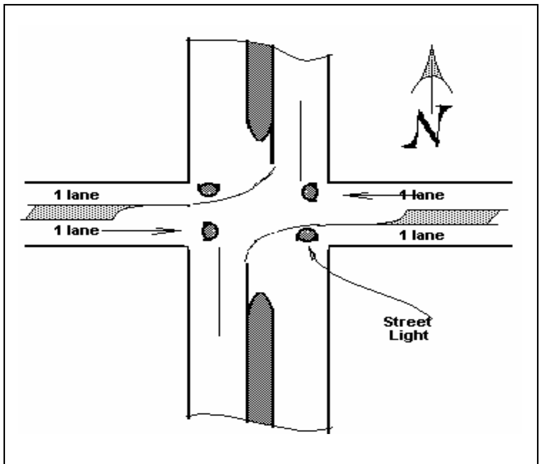

Figure 1. This diagram a used to discuss traffic flow.

2. Design a floating-point multiplier using discrete components.

   Multiplication is a very important operator in mathematics, if it is not implemented in hardware in a computer it can be quite time consuming, consisting of many shifts and conditional adds. Hence time is dedicated to this problem. Again see [1].

Course 2. Assembly Language

This course is based on two machines, the IA32 and the TMS320C3x DSP chip. Some time is spent on the concepts of signal processing. I have not addressed the IA64. The primarily focus of the course is assembly language. But the problems selected for programming come for vector processing and signal processing. They are elementary, but they seem to bring the student to a point where they comprehend the problems of signal processing while learning the techniques of writing assembly language. Generally there is only one case study considered. That case study is selected from:

1. Design a system to reduces the background noise in the communication system between a pilot and the control tower. Your design should in both hardware and software. In the course the item sought is at the software.

   The idea of this problem is to move the problem from the real life situation to a laboratory or classroom environment. From there define a new problem and proceed. The students are then asked how they might solve the new problem? Is it the same problem? One solution almost always forwarded is that of filtering which allows for further discussion concerning signal processing. These concepts are then considered in the light of assembly language programming using either the IA32 or the TMS320. If the system is completely implemented then an experiment is preformed. Subject A is tasked with reading a given statement into the microphone. The output is pushed through the system for transmission to the receiver to be heard by subject B. To minimize the noise that is induced at the source subject B is in separate room.

One approach to this case is to use the LMS algorithm to filter the data. This approach can be found in part in B. Widrow's text Adaptive Signal Processing, [2]. If the TMS320 is selected then a I refer the student to Chassaing's text, [3].

2. Develop a history and a device that is an autonomous filters and signal processing devices.

   The real purpose of this case is to introduce the students to the early work of Bernard Widrow, a pioneer of adaptive filtering. The student must relate Widrow's LMS algorithm to the concepts generally appearing in the theory of Neural Networks. The hope is, some one to replace the filter scheme in Case 1. with a method Widrow called ADLINE. See [2], [4].

Course 3. Computer Architecture.

The goal of this course is to describe the basic principles underlying tomorrow's technological developments. A short history beginning is given. At each stage the computer's architecture is quickly described. Even the more complex mainframes are identified and discussed. Once this history/description is done the course moves to the fundamental of computer design, instruction set principles, parallelism, memory hierarchy design, storage, and networking. Embedded in this course are the following cases:

1. Configure a new computer system for NTEA.

   This case is being transformed into a training module available over the TWU network. The paper by Demuynck, et.al., [5], presents the current state of this effort in greater detail. In this case the student is not building or programming but rather configuring a system. It hoped that they will learn techniques for performing such a task, namely, configuring off-the-shelf products to create a product the customer can use. A good reference for this case is Hennessy & Patterson, [6].

2. Design an automated system for patient monitoring in a cardiac ward. The system should also provide for the delivery of medication. Identify the autonomous component of such a system.

   Clearly this is a very complex problem. The idea is to have the student learn how to decompose complex problems into its smaller components. Clearly this design approach is similar to the top down approach used in computer science. This case would require several references to design a system.

   Because of the complexity the student is required to identify a specific subcomponent for implementation or emulation.

Course 4. Differential Equations.

As always the focus of this course is on the methods of solving differential equations. Only now additional attention is dedicated to the applications. These applications include LRC circuits, The Snowplow Problem, Clairaut's Equation and Singular Solutions, Curves of Pursuit, Feedback and the Op Amp, Bang-Bang Control, Convolution Method, Simple Pendulum, Things that Bob, and Aging Spring and Bessel Functions. All of these problems appear as group projects in Nagle, Saff, & Snider, [7].

Course 5 Topics in EMC

Course 5 is designed to provide the student with a number of elementary concepts from electricity and magnetism as well as a review of elementary concepts from DC/AC circuits. The review of electricity and magnetism moves beyond the general scope of a second semester course in physics by selecting topics from Ehrlick's text on E & M Simulations, [8]. The material on DC and AC circuits is taken from Simpson, [9].

Other Cases:

In addition to the cases mentioned above several additional problems are available for consideration. Some are easy while others are almost impossible. The idea is that in trying to solve any one of them the student learns to extract the essence of the problem and identify the elements and essential sub-problems that must be solved. Listed below are a couple of three such problems.

1. Design a system to ascertain traffic flow. Identify the weaknesses and strengths of your system's design.

2. Design a device to measure gravitational waves.

3. Design a device to detect artificially induce seismic waves.
   For addition information see B. L. Kennett, [10].

Conclusion

The preliminary reaction of the students to these problems of which they generally see on two or three has been positive. Considering the fact that TWU is not an engineering university we are working towards a situation that the potential engineering student, and even those that do not intend to enter the engineering profession, will possess a better understanding of what it means to be an engineer.

Keeping the potential student interested is what this endeavor is all about. And according to Anderson,L., Northwood,D., [11] – "A student retained is a student gained."

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Bibliographical Information

WAYNE J. ZIMMERMANN
Dr. Zimmermann is a Professor of Mathematics and Computer Science at the Texas Woman's University. His current interests include mathematical modeling, analytical number theory, and computer architecture. Currently the author is formulating a nonlinear model of a forest fire.