Integrating Design and Decision Making into Freshman Engineering at West Virginia University

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Introduction

West Virginia University has a long history of developing problem solving and decision-making skills in the freshman year. For more than a decade, Freshman Engineering courses at West Virginia University have followed the ***Guided Design Model*** developed by Professor Wales [1, 2]. In this model the instructor serves as a '***guide on the side***' rather than a '***sage on the stage***' as he directs student inquiry, guides design activities, and provides reflective feedback based on his own knowledge and experiences. Although the Guided Design Model was well developed and widely recognized, there existed a growing perception among faculty within the college that students entering the sophomore year were weak in math and computer skills and had difficulty integrating knowledge.

Recently, pilot Freshman Engineering courses were implemented to address these concerns [3, 4, 5, and 6]. In these courses, specific emphasis was focused on:

- Incorporation of more rigorous design, based on math and science principles into design project activities;
- Reinforcement of math and basic science concepts through parallel treatment of topics;
- Incorporation of engineering design projects taken from real world problems;
- Improvement of mathematics and basic sciences skills through tutoring, help sessions and in-class activities; and
- Improvement of study skills and academic success strategies.

This paper is the second of a two part series. A companion paper entitled "The Freshman Engineering Experience at West Virginia University" presents an overview of the Freshman Engineering Program and describes various programs aimed at improving comprehension of mathematics and basic science courses and developing study skills and academic success strategies [7]. The present paper presents the approach used to integrate rigorous design and incorporate mathematics and basic science principles into the Freshman Engineering Curriculum and presents an example project.

Background

The first year engineering curriculum is usually intended to be a bridge between high school and sophomore level engineering courses by building the requisite mathematics and basic science background required by the sophomore courses. As such, the first year is confounded with math, chemistry and physics courses most of which are taught in isolation from each other ***according to the traditional textbook-centered lecture format.*** In this traditional model, students are evaluated primarily on memorization and recall of discrete facts and theories rather than on mastery of thought processes and intellectual skills. Students respond by ***compartmentalizing*** their technical knowledge without awareness of connections between subjects. Integration and assimilation of knowledge are not effectively addressed and students subsequently have trouble applying knowledge they have learned to new and different problems. During the freshman year students typically have limited contact with the college of engineering. Therefore, a strong introductory engineering course is needed to give students an appreciation of what engineers do and what processes, knowledge, and skills engineers use.

Many models for introductory freshman engineering design courses have emerged. A few of those with goals similar to our own will be mentioned here. A significant portion of efforts aimed at reforming freshman-engineering courses has been focused on developing design project activities. The University of Missouri-Rolla [8] has experimented with large-scale design projects in their freshman programs. Freshman students at Missouri-Rolla designed a human powered generator for use by paramedics in the field. At the University of Maryland [9], students designed, built and tested a wind-powered generator. At Carnagie Mellon University students designed and assembled energy conversion mechanisms using miniature steam engines and Meccano sets to drive a mobile vehicle or to generate electricity for lighting a bulb [10]. The large-scale project is broken into smaller sub-projects that lead to the design and construction of the end product. Most project-based engineering courses attack several smaller scale projects during the semester. As part of the 1996 Enhancement of Faculty Design Capabilities Workshop, sixteen participating faculty members from 13 universities developed 36 design problems ranging in complexity and duration [11]. Projects requiring both individual student work and team efforts were developed and disseminated.

The second major theme in recent engineering education reform is integration and parallel treatment of topics in engineering, mathematics and basic science courses. Arizona State University has developed a freshman curriculum that integrates course work in English composition, calculus, freshman physics and introductory engineering courses [12, 13]. A similar pilot integration was attempted at the University of Alabama [14, 15]. Projects included designing a compressed natural gas storage tank (ideal gas law in chemistry), sizing an automotive catalytic converter (chemical kinetics, balancing chemical reactions) and designing an harmonic oscillator. In the more advanced projects, students were provided with the necessary equations. The faculty involved in this pilot study noted that it was difficult to determine the correct mix of background information that should be provided to the students without making a “cookbook” problem.

Several of these models have attractive aspects that are of interest to the program being developed at West Virginia University but do not completely fit our needs. Therefore, we combined elements of each into our courses.

Course Content

At West Virginia University, all freshman-engineering students undergo a common curriculum. Students are required to take a sequence of two freshman engineering courses emphasizing design, problem solving and computer programming. The Freshman Engineering sequence consists of two courses: Engineering 1 (E1) and Engineering 2 (E2). The objectives of E1 are (1) to insure a level of basic computer literacy, (2) to develop problem solving and group work skills, (3) to enhance written and oral communications skills, and (4) to develop awareness of the different engineering disciplines and the engineering profession in general. The objectives of E2 are to enhance students' problem solving skills and to develop ability with the C programming language and with the MATLAB software package. Both courses traditionally involve projects as a vehicle for group work and problem solving. Each of the twelve sections has approximately 40 students and is taught by faculty from the various departments within the College of Engineering and Mineral Resources.

The new courses comprise several projects, which involve mathematical models developed from fundamental scientific principles by the students rather than simple formula-centered problem solving strategies. The projects build in complexity, each asking more of the students than the last. The design projects are formulated so that the pieces of the puzzle in Figure 1 fit together to complete the decision-making process for design.

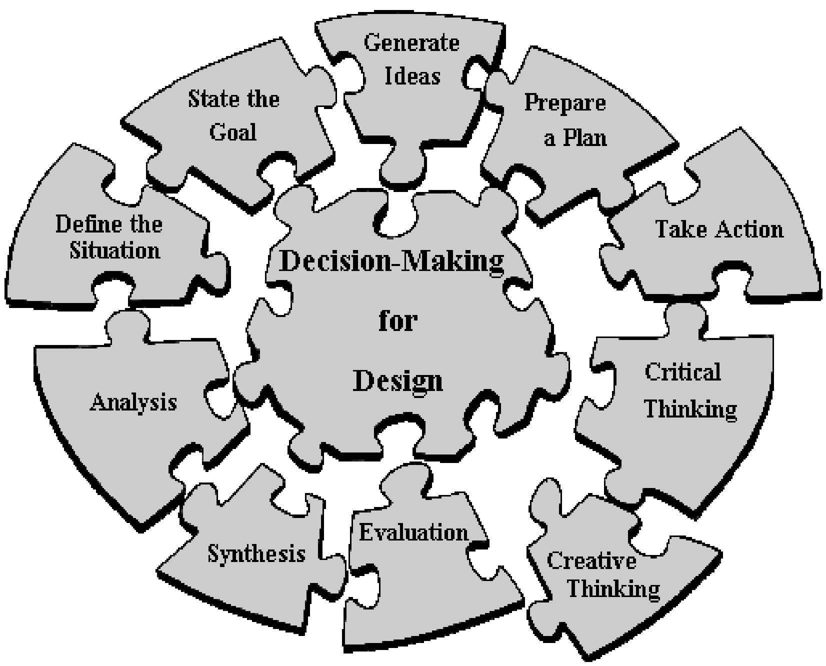

Figure 1: Decision-Making Process Puzzle

Projects are chosen based on the following attributes:

- Projects must be of a complexity that requires the use of computer for solution.
- The mathematics necessary must be understandable by any student accepted into the College as a freshman-engineering student. At West Virginia University, only 60% of the students are qualified for the first calculus course. The remaining students register for the pre-calculus course.

- Equations necessary for solution should be derived from first principles or observations. We avoid situations where the complexity of the problem requires equations to be provided to the student without an understanding of their origins.

- Projects should involve concepts that reinforce the importance of mathematics and science courses taken outside of the College of Engineering and Mineral Resources and present topics in parallel with these courses.

- Projects should be applicable to different engineering disciplines to allow students to make a realistic assessment of their interest and aptitude toward the selection of a specific engineering major.

One example of a first project, described below, is the Rodent Control Project. In this project, students are asked to reestablish a natural balance of a rodent population in an agricultural environment that has been upset by trapping and removing the rodents' natural predator. The students are required to develop a predator-prey relationship based on their own observations and understanding of the system and to design a trapping mechanism to eliminate the excess population. This project encourages students to use their own knowledge to develop a mathematical model of the system. It introduces them to some simple mathematical relationships and to the scientific method. This particular project is well suited as a first project because it largely stands alone and does not require any concepts that were not introduced in high school math and science courses.

The final project requires more sophisticated mathematics and modeling, and is timed to correspond with topics covered in freshman chemistry. Two projects have been used. One project involves the design of a 25-hp slider-crank internal combustion engine. Here students used trigonometry to develop the equations of motion for the slider crank mechanism, used chemical analysis to determine the heat released from combustion of the fuel and used the ideal gas law to determine pressures and hence work, power and torque. The model equations were entered into a spreadsheet and plotted as a function of crank position. Each group of students were given a different fuel and asked to design the physical dimensions of the engine to produce 25 hp without exceeding a specified maximum piston velocity.

An optional second project is the design of a steam-powered car. In this project students were asked to design a steam-powered miniature car to travel as far as possible on 20 ml of ethyl alcohol fuel. This project was inspired by the Micro Steam Car Challenge organized by the Mechanical Engineering Department at the University of Natal in Durban South Africa [16]. The project was also scheduled to coincide with the presentation of thermochemistry and energy related topics in the freshman chemistry course. Although students may not be simultaneously enrolled in physics, the necessary concepts such as Newton's laws of motion, conservation of momentum, and impulse-momentum can be easily developed with examples taken from everyday experiences. Here the students also used chemical analysis to calculate the heat released from combustion of the fuel. They used the concepts of specific heat and latent heat of vaporization to determine how much water to put in the boiler and the pressure within the boiler. Finally, students were encouraged to apply simple equations provided by the instructor to calculate the force applied to the turbine by the steam exiting from the boiler. Based on these calculations, the students designed and constructed their vehicles and competed in a distance event.

An Example Project

The problem was introduced to the students in the form of a story told by the instructor about his experiences as a youth on a dairy farm. ***This narrative played an important role in capturing the interest of the students and in personalizing the relationship between the students and the instructor. This was a very important step to the maintenance of open communication with the students.*** The narrative described an activity in which the natural balance of predator control was upset. Foxes on the farm were caught and sold for profit. The rat population, which was the food source for the foxes, went out of control and a new balance had to be obtained. The party responsible for causing the imbalance (the instructor) had to re-balance the system using only the profit gained from the sale of the foxes. ***This illustrates an important tenet of the engineering profession, responsibility. Engineers must take responsibility for their activities. The second lesson in the project is that profits made by selling the foxes must be used to develop the methods for controlling the rat population. Engineering success is directly related to economic values. If the solution is not economical then it is not a solution.***

Problem Discovery: After students had read the problem statement many of them thought they immediately knew how to solve the problem. Some of them even sketched potential candidate solutions. ***At this point, the instructor encouraged a discussion of the thinking process employed to develop those fast candidate solutions. He must show the students what is missing from that thinking process. The problem has not yet been fully defined and understood. Many important questions must be answered before a solution can be sought.*** The students were encouraged to refine the problem by focusing on the conditions. What must be known before a proper solution can be developed? An exercise in brain storming occurred to answer that question. Just how many rats have to be eliminated? At what rate must the rats be eliminated to balance the population in a reasonable period of time? What is the rat population doing during the time interval for elimination? ***This exercise showed students that what appeared to be a simple gee-whiz problem is actually a fairly sophisticated task. They realized the need to get more information.***

Group Development: It is realized that this problem is too large for a single student. Groups need to be formed. ***It is important to understand that the students were not simply divided into groups but that they recognized the need for cooperation among themselves.*** The class was divided into manageable size groups usually consisting of 5 or 6 students and each group was asked to formulate a solution to the problem. ***The instructor monitored this division to insure that groups were fashioned in an equitable manner, that is, mathematical abilities and experience working with computer and software tools were equitably distributed.*** Each group elected a leader or spokesperson. At this point the students often asked the question, "What if we don't get the right answer?" So far in their education, they have become accustomed to one right answer to every question. ***The instructor must convey that in design there may be several correct answers each with its own set of advantages and disadvantages.*** For example, there are many types of can openers on the market today. They all open cans; therefore, they are all right answers. The instructor should make it clear that each group will likely arrive at a different solution to the project and that each solution will be a right answer. ***We feel that it is not healthy at this point in the educational process to encourage strong competition between groups.***

Information Gathering: ***A fundamental engineering tenet is that no problem can be solved without information about the system.*** But first, one needs to understand what information is needed. A discussion followed as to what information was required and where it could be obtained. This process relied on engineering estimation. The students were asked what they think. How many rats comprise a litter? How long is the development time for rats before they can breed? Essentially, the pertinent questions were posed to the class to stimulate discussion and discovery. The individual groups selected and categorized the information needed to generate a solution of the problem. ***In this process, the instructor reviews the information sets and directs the groups by asking relevant questions. The instructor gives the students freedom to follow a blind alley before directing them back on course.*** At this stage in their education, students do not know how to follow a logical approach toward a solution. ***The students must learn to recognize when they have reached a dead-end or drifted off course.*** As the problem developed each group member had a specific set of information gathering tasks assigned by the group leader. ***The instructor must use caution to ensure that the workload is divided evenly among the members of the group. Left to their own devices, some students like to carry the entire load and leave nothing for others in the group to do.***

At this point the students were acquainted with the university library system. A library tour or class visit from the university librarian was organized. The librarian was previously acquainted with the problem so the students could be shown how to get information, which is appropriate to the problem at hand. The second approach was to acquaint the students with the Internet. For some, this was their first use of the computer. ***It is imperative that all students have hands on experience with the Internet search.*** The searches either confirmed or rejected the numbers determined through engineering estimation exercises.

Development of a Mathematical Model for Rat Growth Analysis: The students were asked to make estimations of litter population and breeding age for rats based on personal observations and best guesses. A general agreement among the class was reached. A litter consists of 8 rats and that the time interval for breading is 81 days. (Different classes have different values, but they do not vary dramatically from the values above.) From this data the students formulated a population growth pyramid. Starting with 2 rats, the first breeding interval produces 8 new rats plus the original 2 rats, totaling 10 rats. For each breeding interval thereafter the conditions are that for every 2 rats an additional 8 rats are produced. Starting with 10 rats in interval 2, 10/2 X 8 +10 = 50 rats are present. At breeding interval 3, 50/2 X 8 +50 or 250 rats are present. After 324 days, the number of rats has increased from 2 to 1250 - a lot of rats. The formula for the number of rats produced at the n^{th} breeding interval was then derived.

A plot was made from the number of rats present verses time (see Figure 2). The curve represents a standard function and the students were asked to identify the function. The instructor suggested that the log of the number of rats be plotted against the number of days (see Figure 3). It readily becomes apparent that the function is exponential. The students were asked if they have any knowledge of such functions, in a similar application. Usually, someone in the class had studied bacteria growth curves or radioactivity decay functions and recognized the function. The students were asked to check bacteria growth or some similar example. ***This teaches the value of associated knowledge. A fundamental key to successful engineering design is the ability to apply previously learned knowledge to new situations.*** A standard exponential growth equation was derived and terms in the growth curve were explained.

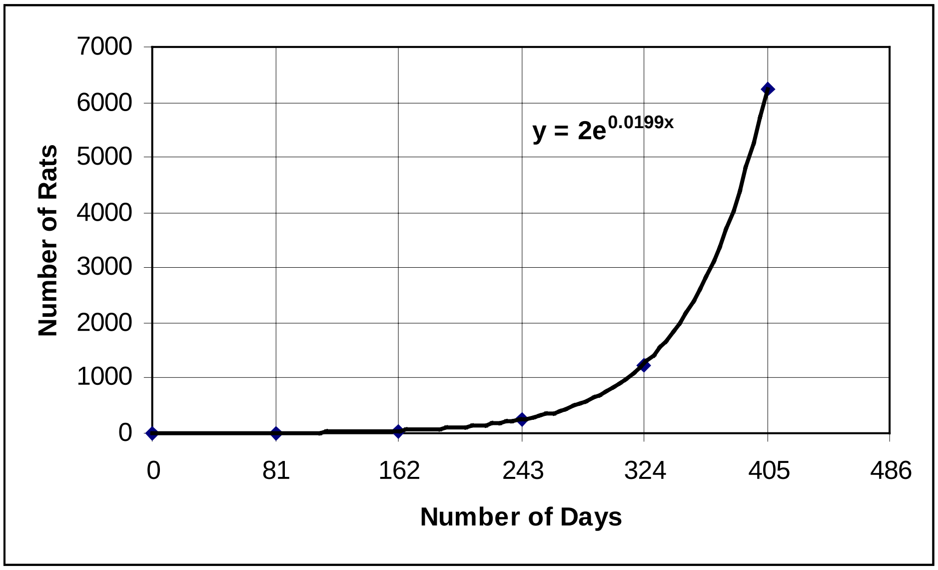

Figure 2: Rat Population Growth

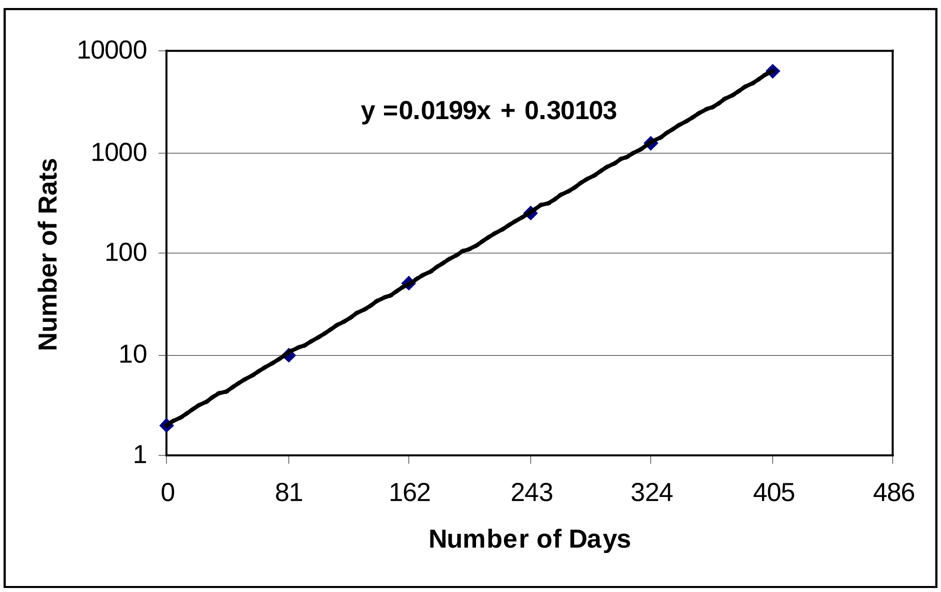

Figure 3: Semi-Log Plot of Rat Population Growth

Equipped with this mathematical equation, the population of rats can be determined at any time provided there is no *natural death.* ***Attention was drawn to the fact that an assumption is being made to simplify the calculations and that this is a common practice in engineering. Some discussion was encouraged as to how this assumption may affect the results and whether it is a good assumption to make.*** It readily becomes apparent that there is a tremendous potential to populate the area with rats.

Predator-Prey Analysis: The question then arose: where do all the rats go? Foxes limit the population by the process of natural predation. To appreciate the role of the foxes something must be known about the fox population. How many foxes are there in a given area? How many rats will a fox kill in a given day? These questions required more information gathering using the library system and the Internet. A logical answer is that there are 26 foxes per square mile in the area of the farm. If each fox eats a rat and a half per day, how many rats are needed daily to supply the fox population? Twenty-six foxes will dispose of 26 X 1.5 = 39 rats in a day. The maintenance population is that number of rats needed to supply 39 fresh adult rats per day. If 20 foxes were eliminated, only 6 would remain and that would require a population of rats that will supply 9 new rats per day. The students were asked how to determine the number of rats required. Of course, this can be directly calculated from the growth rate equation. The students determined that they must reduce the rat population from 1,995 rats to 448 rats. The scale of the problem was much greater than they had originally envisioned. ***The step of mathematically defining the design boundary conditions is a critical step in the design process. Without valid boundary conditions, engineering design is impossible.***

The students quickly realized that eliminating 1,547 rats was not going to happen overnight. Therefore, the rate of rat elimination needed to be taken into account. Why? Because the rats are continuing to propagate according to the exponential growth curve while the trapping is occurring. If in the first day, 55 rats are trapped and the 6 foxes kill an additional 9 rats, then the breeding population will be 1949 rats. These rats continue to breed according to the growth curve producing

$$X = 1949e^{0.0199} - 1949 = 39\, new\, rats$$

in a one day interval. Therefore, the breeding population for the next day is 1942 rats. Repetition of this calculation yielded a decay curve from which the time period necessary to reach the new maintenance population was determined (see Figure 4).

<u>*The need for using spreadsheets:*</u> The above calculation must be repeated a large number of times in order to determine the time period necessary to reduce the rat population**.** ***The students quickly realized the need for a software tool to eliminate the tedium.*** The best way to do the calculations was through the application of a spreadsheet. A discussion of the principles of the spreadsheet was presented using the most fundamental processes. The growth curve equations were set up and a discussion of data entry was provided. The selected software package was explained. Students were taken to the computer lab and re-introduced to the computer. The mechanics through which they can access the spreadsheet software was demonstrated and the students were then required to enter the data and complete the calculations. Their success was demonstrated through a printout of the spreadsheet and a plot of the growth and decay functions.

From the plot the students determined that they must kill a greater number of rats than the original number of foxes eliminated per day in order to reduce the overall rat population. After completing a few days reduction they were able to calculate a population reduction curve and determine the number of days required to re-balance the predator-prey relationship given a specific daily elimination rate. In order to determine the daily elimination rate, the number of rats eliminated is subtracted from the balance rat population, and the rat number of new rats that this population will produce is calculated. This process is repeated and a population reduction curve is developed. From the exercise the students learned how long it would take to re-balance the rat population at a specific daily elimination rate. Using this software tool the students could experiment with different elimination rates and decide what trapping efficiency is required from their design.

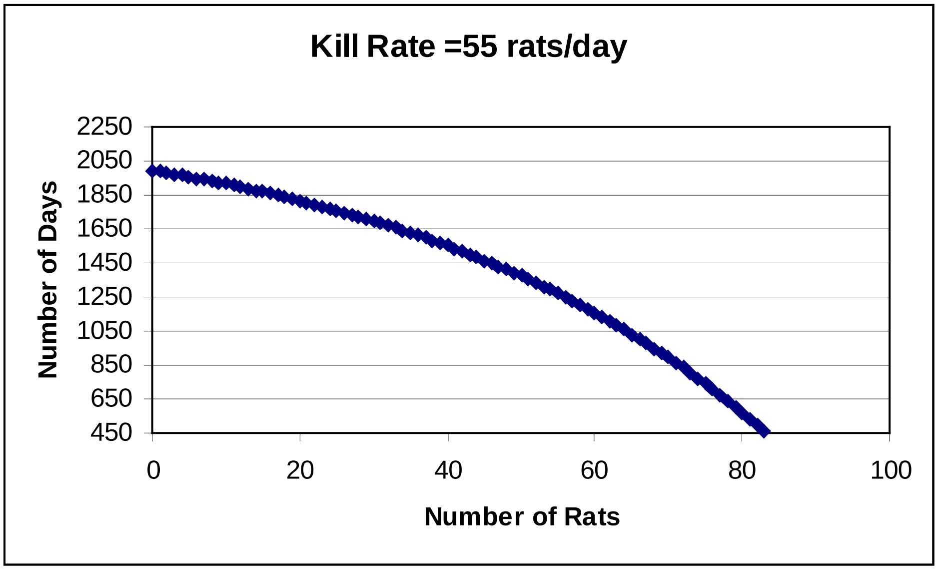

Figure 4: Rat Population Decay Curve

<u>*Designing the Trap:*</u> Once that the boundary conditions had been established, the students set about the open-ended task of designing a device to attain the desired elimination rate. Each student group was required to design a device or method to eliminate the rats at their selected rate. The goal was that it must be as economical as possible because they must finance the project from the profits received from selling the foxes. ***This is essentially the second iteration through the design process since at the onset of the project many students had formulated candidate solutions. The process begins again with the generation of a new set of ideas.*** Each group generally had its own design. It must be emphasized that no answer is more correct than any other if they both solve the problem.

At the conclusion of the project, the student groups gave an oral presentation of their approach and submitted a written report to the instructor for evaluation. ***In order to do these tasks the student were exposed to word processing and graphical presentation software. A discussion on technical writing and oral presentation skills was presented. It was expected that this first attempt at technical writing and oral presentations would be unpolished. The instructor must provide a lot of constructive comments and students should be encouraged to incorporate those comments in future reports.***

<u>*What has the Example Project Demonstrated?*</u> The fundamental philosophy of the approach was to introduce basic engineering concepts and expose the student to the engineering profession through integrated projects. Through participation in these projects, students acquired many important skills and become exposed to a variety of aspects of the engineering profession. Some of these are listed below.

- Most importantly, the project exposed the students to the complete design model as it is applied by practicing engineers, including rigorous definition of the design boundary conditions and evaluation of candidate designs against those conditions. This involved the critical thinking, evaluation, synthesis and analysis, processes of the design.

- The project exposed the students to some fundamental scientific and engineering principles without overwhelming them with mathematics. The typical freshman student can easily understand the level of mathematics involved in the calculations. Concepts were developed from the fundamental principles so that a basic understanding was developed.

- The students were also exposed to the concept of engineering estimation, a process which practicing engineers often employ in order to judge the correctness or accuracy of a solution to a complex problem. The fact that engineers are often required to make simplifying assumptions in order to calculate a solution was also illustrated by assuming that there was no *natural death* in the rat population.

- The application of prior knowledge to new situations was demonstrated by making the association of the rat control problem with the exponential growth of bacteria or radioactive decay. This reinforced the importance of mathematics and science classes taken outside the domain of the engineering college.

- Since the project involved multilevel calculations, which require more than the calculator, the students were given much more than a cursory introduction to spreadsheet software programs. This type of project could just as easily be employed to teach programming languages, or other analysis packages such as Matlab or MathCad.

- The students were shown the importance of gathering relevant information before proceeding with the design process. They were introduced to multiple sources of information such as the library system and the Internet and were taught to make use of various automated search tools.

- The importance of teamwork was demonstrated. This was accomplished not through force but rather necessity. The students were permitted to come to this realization rather than simply placing them into groups at the onset of the project. Giving team grades on reports and presentations emphasized the importance of the individual to the whole.

- Two important ideologies of the engineering profession, *responsibility* and *economics*, were emphasized through the narrative used to introduce the project. The role of economics played an important part in the evaluation of candidate designs.

- The students were exposed to the challenge of an open-ended design. The fact that multiple solutions exist, each with their own advantages and disadvantages was emphasized. Individual groups were encouraged to be innovative and resourceful in their designs.

- Students were given the opportunity to develop quintessential written and oral communications skills through written reports and class presentations. Skills in the use of word-processing and graphical presentation software were developed.

Results and Conclusions

The results of these pilot courses indeed show that freshman can do rigorous engineering design, based on mathematics and scientific principles. While projects were restricted to ideal situations, they had enough depth and realism to capture the students' imagination, encourage them to apply mathematics and scientific knowledge, and reinforce the content taught in freshman math and science courses. Evaluations made at the completion of the students' junior year indicate that retention of students who completed the pilot program was 20% higher than that of students completing the traditional sequence of courses. Certain tangential findings are perhaps more significant than retention alone when evaluating the effectiveness of the pilot program. Students enrolled in the pilot program were able to work at a higher level of mathematical rigor than previously attempted by freshman in the college. Several students formed durable cooperative study groups that were still active at the end of their junior year. Of the students who left engineering, several have maintained contact with their freshman engineering instructor and have expressed that they still employ the team approach, cooperative study techniques and learning skills they developed in Freshman Engineering. Perhaps most significantly, after completing this program, several students have demonstrated a strong interest in pursuing a career in higher education, and are actively participating as teaching assistants in the Freshman Engineering Program.

The course described in this publication is primarily the first semester course, E1. The same approach to problem solving has been expanded to use more sophisticated multi-level problems in a second semester course, E2. In this second semester, the use of spreadsheets for analysis is replaced by instruction in a formal computer programming language, C. Student evaluations of the computer course taught in this manner have been much more positive than when the language was taught in a traditional format. In fact, faculty using the problem solving approach has been able to increase the depth of content over that taught in the language-programming course in previous years. For information on problems used in that course, contact the authors of this paper.

Bibliography

1. Wales, C., Nardi, A., and Stager, R., Thinking Skills - Making a Choice, West Virginia University Center for Guided Design, 1987.
2. Wales, C., "*There is a 'How to Teach' Frontier*", Proceedings of Frontiers in Education Conference, IEEE, New York, 1978.
3. Stiller, A., Venable, W., and McConnell, R., "*Incorporating Study Skills in a Freshman Engineering Course*," 1995 Frontiers in Education Conference Proceedings, IEEE, New York, 1995.
4. Venable, W., McConnell, R., and Stiller, A., "*Incorporating Mathematics in a Freshman Engineering Course*," 1995 Frontiers in Education Conference Proceedings, IEEE, New York, 1995.
5. McConnell, R., Venable, W., and Stiller, A., "*Freshman Can Do Rigorous Open-Ended Design*," 1995 Frontiers in Education Conference Proceedings, IEEE, New York, 1995.
6. Venable, W., McConnell, R., and Stiller A., "*Follow-Up of a Freshman Engineering Course Experiment*," 1997 Frontiers in Education Conference Proceedings, IEEE, New York, 1997.
7. Craven, K., Wayne, S., and Stiller, A., "The Freshman Engineering Experience at West Virginia University," 1999 ASEE Annual Conference and Exposition, Charlotte, NC, 1999.
8. Fannin, D., Bryson, T., Carney, E., Carrol, D., Koen, M., and Oster, K., "*Freshman Design/Construction Projects Conducted on a Large Scale: Student and Faculty Opinions and Outcomes*," ASEE Midwest Section Meeting Proceedings, Tulsa, http://me8.me.utulsa.edu, 1996.
9. Regan, T., "*Design and Manufacture of a Wind Generator*," ECSEL: Introduction to Design Engineering, Active Learning Modules A Catalog, http://echo.umd.edu/, 1993.

10. Ambrose, S. A., and Amon, C. H., "*Systematic Design of a First-Year Mechanical Engineering Course at Carnegie Mellon University*," Journal of Engineering Education, Vol. 86, No. 2, pp. 173, 1997.

11. Lovas, C., and Packman, P., "*Enhancement of Faculty Design Capabilities*," Proceedings of the 1996 ASEE Anual Conference, Session 2625, Tulsa, http://me8.me.utulsa.edu, 1996.

12. Evans, D., Doak, R. B., Duerden, S., Green, M., McCarter, J., Roedel, R., and Williams, P., "*Team-Based Projects for Assessment in First Year Physics Courses Supporting Engineering*", 1997 Frontiers in Education Conference Proceedings, http://fairway.ecn.purdue.edu/~fie/fie97, Pittsburgh PA, 1997.

13. Rodel, R. J., Evans. D., Doak, R. B., McCarter, J., Duerden, S., Green, M., and Garland, J., "Projects that Integtrate Engineering, Physics, Calculus, and English in Arizona State University Foundation Coalition Freshman Program," 1997 Frontiers in Education Conference Proceedings, http://fairway.ecn.purdue.edu/~fie/fie97, Pittsburgh PA, 1997.

14. Parker, J., Cordes, D., Laurie, C., Hopenwasser, A., Izatt, J., and Nikles, D., "*Curriculum Integration in the Freshman Year at the University of Alabama - Foundation Coalition Program*," 1995 Frontiers in Education Conference Proceedings, http://fairway.ecn.purdue.edu/~fie/fie95, Atlanta GA, 1995.

15. Parker, J., Cordes, D., and Richarson, J., " *Engineering Design in the Freshman Year at the University of Alabama - Foundation Coalition Program*," 1995 Frontiers in Education Conference Proceedings, http://fairway.ecn.purdue.edu/~fie/fie95, Atlanta GA, 1995.

16. "*The International Micro Steam Car Challenge*," Department of Mechanical Engineering, University of Natal, Durbin 4001, South Africa.

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DR. ALFRED STILLER, Professor of Chemical Engineering has been involved with the Freshman Engineering students and their learning for over a decade. His approach is very different from the traditional style familiar to most teachers. He is extremely well received by his students and a number of freshman instructors have requested him to train them with his successful techniques.