Interdisciplinary Approach to First-Year Engineering Curricula

Jo Howze, Jeffrey Froyd, Kristi J. Shryock, Arun R. Srinivasa, Rita Caso
Texas A&M University, College Station, TX

Abstract

With support from the STEM Talent Expansion Program (STEP) of the National Science Foundation, the Texas A&M University Engineering Program (TAMU) is drawing upon existing results to construct an improved learning experience for all engineering majors. Drawing from integrated curricula/learning community initiatives, physics, engineering, and mathematics faculty members are working together to help students more closely link concepts from the three subject areas. Faculty members have constructed specifications that design projects must follow to help students build tighter connections among the three subjects. A comprehensive assessment and evaluation plan has also been designed and implemented. This paper will describe the integration mechanisms, project specifications, and systems to address study skills, as well as data that has been collected and analyzed to date. Future assessment plans and strategies for expanding the program for more students and extending it to two additional first-year engineering tracks will also be described.

Introduction

First-year engineering curricula have been identified as significant opportunities to improve four-year engineering curricula, and many institutions have addressed the opportunity in different ways. At Texas A&M University (TAMU), at least four challenges were identified with respect to first-year curricula in the Dwight Look College of Engineering. These challenges are not unique to TAMU and avenues for addressing these challenges might be applicable to other institutions.

Challenge 1. Despite the innovations introduced during TAMU's participation in the Foundation Coalition [1], retention of engineering students after one year still requires significant improvement [2-6].

Challenge 2. Engineering students require clearer understanding of the value and relevance of science and mathematics. Statements made by engineering students at University of California Berkeley are typical of statements by engineering students about mathematics and science courses.

> *"Well, mathematics is, basically…abstract…unless you apply it to something you don't have a physical foundation… It's more conceptual, you have to be able to manipulate symbols…You got to get over the fact that it may seem pointless, and just do it. That's probably one of the hardest things in math, that there's no reward, there's no tangible physical thing that you have. You didn't find out how far this ball is going to fly, or how long it will take for this thing to cool down. You have a number, and you can't do anything with this number." and*

> *"The problems in math have absolutely no significance at all. It's purely an exercise." [7]*

Challenge 3. Engineering faculty at larger institutions, such as TAMU, generally lack knowledge of the first-year student experiences and content of first-year engineering, science, and mathematics courses. Often to the extent that they are familiar with the content of the first-year engineering courses, they are critical of the content because it has little or no direct relevance for the disciplinary subjects taught by the faculty members.

Challenge 4. Students often lack exposure to learning experiences that help them to understand what and how engineers create. Students often fail to grasp the nature of and how their courses are connected with engineering practice.

The Engineering Academic Programs Office (EAPO) at TAMU intended to address these four challenges as it revised first-year engineering curricula.

At least two alternatives have been pursued at other institutions. First, many different engineering programs have either included projects in their first-year engineering courses or structured the entire first-year course around one or more projects [8,9]. Projects are intended to acquaint students with the engineering design process and provide opportunities to practice the application of the design process. Also in many cases, students, through working on projects, often perceive the relevance of mathematics and science and see how what they have learned in these courses might be applicable to their current project. Another, less frequently used alternative is a first-year course built around discipline, laboratory-based learning experiences [10]. The goal of this alternative is to help first-year students better understand the nature of the different engineering disciplines through carefully crafted experiential learning experiences. Given that one of the challenges faced by the first-year engineering curricula at TAMU was the lack of understanding of engineering practice, EAPO selected the project-based approach. The design challenge could be framed as follows: Can Texas A&M University craft a first-year program that addresses the four common challenges in a form that can be offered to all engineering students and sustained without additional funding?

Design Decisions for the First-year Engineering Curricula

Design Context

In order to understand the design decisions that were selected and implemented, it will be helpful to provide some background information. All first-year engineering students take two semesters of calculus, two semesters of physics, and two semesters of engineering at TAMU. EAPO elected to concentrate its resources on these six common courses. As part of its participation in the Foundation Coalition, TAMU had already clustered students taking engineering, calculus, and physics. That is, most students taking calculus, physics, and engineering are in the same cluster of 100 students. Data from the 1998-99 and 1999-00 academic years showed that students who participated in the clustered sections were retained at a higher rate and completed the courses required for entry into the sophomore courses more rapidly [1]. Also, as part of their work on first-year engineering curricula in the Foundation Coalition, faculty who taught the first-year engineering courses emphasized team training for the students and team-based learning experiences [1]. Beginning with the 2003-04 academic year, the College of Engineering created three different tracks for first-year engineering students, depending on their major. Students who had elected to major in Aerospace, Civil, Industrial, or Mechanical Engineering were assigned to Track A. Students who had elected to major in Computer or Electrical Engineering were assigned to Track B. Students who had elected to major in Biomedical, Chemical, or Petroleum Engineering were assigned to Track C. Content of the two first-year engineering courses in each track was modified to reflect the goals of faculty members in departments associated with each track. However, if students changed majors, courses in any track are satisfactory for completion of the first-year engineering courses.

Design Project Specifications

To address the three challenges, the Colleges of Engineering and Science agreed that the mathematics, physics, and engineering departments would work together to create new learning activities while retaining three separate courses. Learning activities would be designed to enhance student learning and performance in mathematics, physics, and engineering and clarify the importance of science and mathematics for engineering practice after graduation. Students would have a better idea of why learning scientific and mathematics concepts would be valuable and useful. The central foci of the learning activities would be engineering projects. Students working on each project would knit together concepts they were seeing in different courses to address the requirements of the project. Another important type of learning activity would be laboratory activities in mathematics and physics that would be directly related to the project. Students would be engaged in "hands-on, minds-on" activities that would be connected to the current project. Clearer understanding of the relationships among the concepts, clearer understanding of how concepts might be applied to address project requirements, and clearer understanding of how learning in the first year might be applicable to practice after graduation will address the first two challenges. Working with every department to design the learning activities so that they might be used for entire colleges, as opposed to working only within the context of a pilot program, will address the third challenge.

Since engineering projects form the core of the new learning activities, careful design of the projects is critical. Three principles are being used in the design of the projects. First, students must be able to plan before they build. Students must be able to construct mathematical and/or physical models of their proposed design and predict its performance before building. For this reason, students will assemble their design from precision components so that the performance of the design depends upon the arrangement of the components and not on their craftsmanship in fabricating the individual components or their assembly. For an example of the role of precision components, please see the description of the truss project below. Also, the projects must be selected so that required analyses can be performed with the concepts and analytical tools students have available during the project duration. Second, students must be able to use the concepts they are learning in science and mathematics to analyze the performance of their proposed design. In this way, students can see by doing how concepts in mathematics and science can be applied to analyze and predict performance. Students must be able to apply sometimes abstract concepts from mathematics and science to performance prediction. Third, students must be able to transfer learning from concept-based courses, such as mathematics and science, to project-based activities, which form the majority of the engineering design courses.

Support must be provided in the form of (1) coordinated curricula so that the projects draw upon concepts that students are learning, (2) faculty members who are knowledgeable about concepts and activities in all three courses: engineering, physics, and mathematics so that faculty members are able to refer to concepts and activities in other courses when they are presenting learning activities in their own courses, and (3) project materials that help students to see which scientific and/or mathematical concepts are applicable to their projects. Projects built upon these three principles are seen as likely to address the three challenges identified at beginning.

Two projects were developed for the first semester of the first-year program. The first is building a bridge for which the maximum load to be supported might be predicted with considerable accuracy. The second is designing a scale model of a wheelchair lift using a four-bar linkage. Laboratory experiments in both mathematics and physics supported project development. Each project will be described in greater detail below.

Learning and Study Skills Inventory (LASSI)

One element of the approach to improving retention was to work with the entering students on their lifelong learning skills and strategies, which addresses the first challenge presented. An earlier study [11] with the Learning and Study Skills Inventory (LASSI) [12-14] had suggested that entering engineering students at TAMU would benefit substantially from improvements in ten areas that Dr. Claire Weinstein, who developed the LASSI, has indicated are required for strategic learning: anxiety, attitude, motivation, information processing, test strategies, selecting main ideas, concentration, self-testing, study aids, and time management. In an effort to help entering students improve their skills in these important areas, faculty members offered students an opportunity to take the LASSI at the beginning of the fall semester, work with ten modules that had been prepared to help students improve in each of the ten areas, and take the LASSI at the end of the fall semester. Students were offered extra credit for participation in each of the three activities: pre-test, modules, and post-test. Initial results were promising. Given the opportunity to take the LASSI as a pre-test, 140 students took the pre-test. Results were comparable to results for entering engineering students reported in the earlier study. As the average percentile scores for each of the ten scales shown in Table 1 demonstrate, students would benefit significantly if they improve their skills in each of the ten areas.

Table 1. Average Scores on LASSI Pre-test

LASSI Scale	**Average Percentile Score**
Anxiety	62.5
Attitude	30
Motivation	50
Information Processing	60
Selecting Main Ideas	55
Test Strategies	45
Concentration	45
Self Testing	45
Study Aids	40
Time Management	40

Conversations with Weinstein indicated that entering engineering students would be expected to score at or above the 90th percentile. As the results show, there is considerable room for improvement, since higher scores are desirable for each scale. One scale that requires some interpretation is the Anxiety scale, which is designed to assess how much students worry about their performance in school and how they cope with their anxiety. A low score would indicate that students worry a lot and do not have adequate mechanisms to cope with their worries. In an attempt to improve LASSI scores, students could work on two modules of their choice every two weeks with the goal that students would complete all ten modules before the end of the fall semester. Unfortunately, only 29 students who took the pre-test completed one or more of the modules, even though almost all of the students completed the first-year engineering course. The project team did not generate sufficient interest among the students in completing the modules. This was a missed opportunity because it was thought students could significantly improve their productivity for learning if they worked with the modules and increased their performance in each of the ten areas. Also, only 27 students took the LASSI as a post-test. In the future, faculty members will increase their efforts to persuade students to invest some of their time to improve their learning skills and strategies.

Calculus

The first-year calculus sequence retained the traditional lecture-quiz-homework format but modified the recitation activities. Calculus students have learned Maple in conjunction with mathematics concepts for several years. Engineering faculty members have emphasized the importance of MATLAB for upper-level engineering courses and have indicated that first-year engineering students should become more competent in their use of MATLAB. Therefore, the STEP sections of calculus utilized MATLAB and Maple in tandem. They developed MATLAB projects to complement the engineering design projects and focused on mathematics as a tool for analyses that are required as part of the engineering projects. To help students learn MATLAB, a lecturer in the Department of Mathematics developed a set of streaming videos that students could access at any time from the web. Many students commented on how helpful these were and indicated that additional MATLAB streaming videos would be welcomed. Finally, the department offered an additional Week-in-Review session that focused on integration aspects with engineering and physics. Students attended the existing Week-in-Review session to strengthen their experience in seeing problems worked and explained. The additional Week-in-Review session provided additional practice in linking mathematics with physics and engineering.

Students in STEP sections during Fall 2004 appreciated the comprehensive organization of the course where everything that was expected of them was laid out in advance. However, they questioned the use of MATLAB in the course when other Math sections learned MAPLE. This will be become more apparent to them in subsequent courses. For students to become familiar with the "Cycle of Life," a systematic way of working in MATLAB that will be useful in their engineering courses, additional MATLAB sessions will be held by the department in future semesters.

Physics

The first-year physics sequence was modified in two substantial ways during Fall 2004. The order of topics was shifted so as to more closely correspond to the concepts needed for the engineering projects. In particular, the notions of torque, angular velocity and acceleration, and angular momentum, and the laws relating these quantities, preceded the study of work and energy. The laboratory experience was modified so new experiments that directly related to the engineering projects were added. For example, an early lab that previously considered static equilibrium of a point and focused only on forces was modified to include an extended body and the consequent consideration of torques. Labs for the determination of the tensile strength of the bridge components and the study of the torque-RPM characteristics of a motor replaced traditional physics labs, which were less relevant for engineering students.

Fall Semester Projects

Two projects were used in the fall semester of the 2004-05 academic year. In the first project, students built a bridge from Supermag® magnetic kits to span 4.25 inches and support a predicted maximum load [15]. For the second project, students built a scale model of a wheelchair lift using a Lego Mindstorms™ kit. They had to predict the amount of time their lifts would require to raise a model wheelchair to the maximum height and lower it again to the ground.

Many groups of students have engaged in bridge-building contests and activities [16]. However, very few groups of students are required to accurately predict the maximum load that the bridge will carry before the bridge is constructed. Many bridges and fabricated designs for student teams are evaluated using maximum load as the performance criterion. However, most teams are not evaluated according to the accuracy of their prediction of the maximum load supported. Therefore, most bridge-building activities do not follow one or more of the three principles for project development that were described above. Further, if students are asked to predict the performance of their designs, the predictions should agree with actual performance to a high degree of accuracy to foster confidence that their analytical tools are helpful in performance analysis. Since performance estimates would be expected to predict performance accurately, students needed to build their bridges from quality components in such a way that performance depended on the quality of the design and not on the quality of fabrication. If students constructed a bridge by gluing Popsicle sticks together, then it would be very difficult to predict the maximum load the bridge would support since the Popsicle stick bridge is not adequately modeled as a truss, which has only ball joints. Therefore, bridges were built from magnetic sticks and steel balls. Failure in such a structure depended only on the force required to separate a ball from a stick and that force could be easily measured. Also, the force does not vary much. Through the design and analysis process, students integrated their knowledge of physics, mathematics, and engineering in design, analysis, assembly, and testing of the bridge.

For the proposed STEP project, students constructed their bridges from magnetic struts and steel balls. They designed their bridges as linked, two-dimensional trusses. With these constraints, students could use the method of joints to analyze their designs and predict the maximum load supported by each design. The analysis process helped students see how knowledge of vectors, forces, moments (or torques), and solutions to simultaneous equations they acquired in the mathematics, physics, and engineering courses could be used in engineering design and analysis.

Initially, four-student teams were asked to build a bridge to span 4.25 inches using a kit with magnetic sticks and steel balls and then sketch their completed design. In the next class, teams were handed a sketch of a design built by another team and asked to recreate the design. This part of the exercise helped students see the importance of drawings that would enable other people to build from their drawings. Next, student teams were asked to load the design until it failed. Maximum loads were recorded for each design. Then, teams were asked if this was how they thought bridges were designed and constructed to carry specified maximum loads. Puzzled looks, thoughtful looks, and comments suggested this was the first time many students had actually thought about how a structure might be designed and built to satisfy specifications. They had more understanding about the need for analysis of structures. Students were introduced to vectors in the calculus class, forces and moments (torques) in physics laboratory experiments, and joint analysis in their engineering class. Working with students on joint analysis showed that they needed significant improvement in their ability to identify the x- and y-components of several forces acting on a joint, sum the components of the forces, and solve for the unknown forces. More work was required to help students reliably and accurately perform analysis of joints than faculty members anticipated at the beginning of the semester. Nevertheless, students designed a bridge as linked two-dimensional trusses and then analyzed, constructed, and tested their designs by determining the maximum load at a specified point that their bridge would support. Performance estimates agreed with measured results within 10%. This average range of error in predication was consistent with test results conducted in the physics class to determine the tensile load required to separate the steel ball from the magnetic stick. Although identical kits were provided to all student teams, they prepared at least five different truss designs showing there was diversity of designs. Further when predictions did not match measurements, student teams, without prompting, reworked their analyses and found their errors. Faculty members were enthusiastic about results from the bridge/truss project.

A lesson learned from the first project was that the majority of the students required extended lessons on developing free body diagrams and calculating moments to construct equations for static equilibrium. Students had particular difficulty calculating moments when the force applied to an object was neither vertical nor horizontal. The project development was structured so that these concepts were repeated. As an example, moment calculations as part of calculating unknown forces in static equilibrium was required for three parts of the project: 1) determining support reactions of the truss, 2) determining the tensile load of the magnet sticks, and 3) determining the required failure load. Cases 2) and 3) both used the application of a lever to apply a known load to generate a load on the specimen, i.e. magnetic stick or truss.

With respect to the challenge of encouraging interest among engineering faculty members who do not teach the first-year engineering courses, the bridge/truss project was also successful. When faculty members who taught the prototype sections talked to colleagues about the project, either formally, in curriculum committee or departmental meetings, or informally in one-on-one conversations, faculty members reported substantial interest among other faculty members in the civil and mechanical engineering departments. Colleagues who taught sophomore engineering mechanics courses thought students would be more prepared for their courses. Increased interest and knowledge with respect to the first-year engineering courses may encourage more faculty members to teach these courses.

For the second project, students designed a scale model of a wheelchair lift and constructed it using Lego Mindstorm™ kits. These kits were used so that design performance depended primarily on the quality of the design instead of fabrication craftsmanship. Students based their design on either a four-bar linkage or a slider crank design. Students designed a mechanism to lift a wheelchair from ground level to the level of an entrance into a van and then return to ground level. They used their knowledge of derivatives, trigonometric functions, forces, moments, torque-speed characteristics of motors, and mechanism design. The principal design variable was the choice of the gear ratio in the linkage between the motor and the lift mechanism. Students learned how to analyze the position, velocity, and acceleration of their designs. The students had to calculate moments to determine the torque required to raise the wheelchair lift. This information was then used to determine the gear ratio that would allow the motor at a given power level to lift the wheelchair at the specified rate. Initial performance objectives restricting dimensions of the overall mechanism were dropped. This gave the students an opportunity to add bracing, links, gearing as needed so that they could meet the travel requirements and still have a sturdy structure. For the formal analysis associated with the project, students predicted the time to lift to maximum height and the time to travel from ground to maximum height and back to ground again. The variety of solutions that the students prepared was acceptable as there were at least five different design solutions. Once again, performance predictions agreed very well with measured results.

Assessment

Assessment and evaluation plays a pivotal role in both efforts to improve the learning experiences in which students participate (formative assessment) and efforts to evaluate the learning experiences (summative assessment) [17]. The assessment and evaluation plan for this program has been developed to support the achievement of the project outcomes. The assessment and evaluation specialist for the program participates in management team meetings in order to ensure unexpected circumstances and ongoing changes in program implementation are considered in assessing students and evaluating the program.

In Fall 2004, there were six sections of the Track A first-year engineering course, each enrolling approximately 100 students. Two of the six sections (about 200 students) employed the innovative approach described above and were referred to as STEP (treatment) sections. Four of the six sections (about 400 students) retained the traditional first-year engineering curriculum and were referred to as comparison sections. Students enrolled in their freshman engineering courses without knowing whether their section was a STEP (treatment) or non-STEP (comparison) section.

To determine whether first-year retention will be improved, retention of the two groups (STEP and non-STEP) will be tracked. Progression in the freshman engineering program from first to second semester, and retention after one, two, three, four, and five years will be examined and reported for STEP and non-STEP groups. Although improved retention is a critical goal of the project, engineering faculty insist that improved retention cannot be achieved through lower standards. To the contrary, they are very interested in whether students are improving their understanding of mathematics, engineering, and physics and whether they are better prepared for their sophomore engineering courses. In an attempt to ascertain this, program faculty compared

STEP and non-STEP student performance on common problems and questions embedded in course exams wherever possible. Common questions were included on the engineering examinations given in both STEP and non-STEP classes. Students in both the STEP and non-STEP sections also took the same calculus examinations, and common questions were included on the physics examinations given to both STEP and non-STEP students. Performance on the common examinations and/or questions will be analyzed by the project team to determine any differences in the knowledge of physics, mathematics, and engineering between the STEP and non-STEP student. To date, these data have not yet been analyzed, but they will be reported in future presentations and papers.

Student perceptions of the relevance of science and mathematics to engineering as well as their perceptions of their own mastery of key concepts and skills are additional indicators of success in linking concepts and their preparations for future engineering courses. Therefore, the interdisciplinary team designed online instruments to collect data on student perceptions. Students were asked to complete the instruments both at the beginning and the end of the semester so that changes in perceptions might be measured. Baseline data were collected with a pre-test survey of students in STEP and non-STEP classes at the start of the academic year for later comparison with mid-year and end of year survey results. Baseline data indicated little or no difference between students in the STEP and non-STEP groups in their responses to perception survey questions, except that the comparison group expected a slightly higher proportion of fact and formula memorization vs. conceptual understanding to be required in the first engineering calculus course. For example, the question was posed, "Based on your previous educational experiences, what percentage of your combined time and effort do you think you will need to spend on memorizing facts and formulas and/or understanding concepts in Math 151?" Regarding their perceptions of physics, both groups of students also appeared to be similar except with regard to their perception of "How important is knowledge of the principles of physics to most engineering disciplines?" The STEP group believed physics to be more important to engineering than the non-STEP group. T-tests were conducted with 5% confidence level to ascertain the statistical significance of mean differences.

The perception surveys asked several open-ended questions. These responses to the baseline survey were also generally similar for students in STEP and non-STEP groups. However, non-STEP students mentioned expecting to learn computer skills more often than students in the STEP group. Also, they identified the role of math in engineering with problem solving more frequently than the STEP group (61 vs. 22 mentions). In contrast, the STEP group more frequently identified the role of math in engineering as providing a means of communication and common understanding (27 vs. 19) and much more frequently identified the role of physics in engineering as enabling one to "know and understand things" (65 vs. 48 mentions). With regard to the starting equivalence of the STEP and non-STEP classes, the group demographics were examined and were found to be comparable across age, gender, ethnicity, SAT/ACT scores and high school rank. The only difference between the groups was that the STEP group had a higher proportion of first-time-in-college freshmen than the non-STEP group, as evaluated for significance using a Mann-Whitney U test for distribution difference ($z = -3.89$, $p < 0.05$).

In addition, online data on perceptions about learning experiences were collected from students in STEP classes midway through the first semester in order to provide formative feedback for professors and program managers and again at the end of the first semester to assist with planning and preparation for the second semester. Mid semester feedback on instruction, curriculum, and confidence of students in their learning was obtained from 41% (n=75/n=185) of the STEP students who responded to the baseline perceptions survey. In addition, 32% of engineering baseline survey respondents, 18% of math baseline survey respondents, and 18% of physics baseline survey respondents provided data at the end of the first semester. Baseline and two sets of feedback data on the engineering course were obtained from 28% of the 185 students in the baseline set. Results of how the perceptions differed between the two groups at the end of the semester will be presented in future presentations and papers.

Students who complete the first engineering course ENGR 111 in the fall semester continue onto ENGR 112 in the spring semester, and it would normally not matter which section of ENGR 112 they selected. With the implementation of the prototype STEP program, the expectation would be that students who enrolled in ENGR 111 STEP would enroll in ENGR 112 STEP, and students who enrolled in ENGR 111 non-STEP would enroll in ENGR 112 non-STEP; however, there is no mechanism in the registration system to make this happen automatically. Furthermore, students who participated in ENGR 111 STEP might want to continue in ENGR 112 non-STEP. To allow students in ENGR 111 STEP to have first choice for enrolling in ENGR 112 STEP, students in ENGR 111 STEP completed a form regarding their preference for continuing in ENGR 112 STEP. Faculty members teaching ENGR 111 STEP were gratified to learn that 97% of the students in their two sections wanted to continue in ENGR 112 STEP. They regarded this data as indicative of positive student response to the innovations.

Probably most important for both understanding the impact of the STEP program innovation and for influencing attitudes of engineering faculty regarding widespread adoption of the STEP program will be the performance of STEP program students in ENGR 221, a sophomore Statics and Dynamics course. Hence, performance data on the ENGR 221 examinations will be acquired for both STEP and non-STEP students, along with ENGR 221 faculty and student perceptions of student preparation for learning the concepts and skills of that course and other upper division engineering courses. These results will be presented in future presentations and papers.

Future Plans

In the process of asking students to predict performance of designs before construction, faculty members noticed that students were unfamiliar with the concept of mathematical models. When questioned about the concept of a model, most students indicated they thought only about physical models. Since models are critical to engineering analysis and performance prediction, faculty members working on the second semester syllabus are preparing projects to concentrate on constructing mathematical models of physical processes. Faculty members feel students will be better prepared to address questions such as "What is a mathematical model?", "How are mathematical models developed?", and "What role do mathematical models play in the engineering design process?" The importance of modeling was reinforced by the content and activities presented in Starfield, Smith, and Bleloch [18]. Some of the specific activities described below were influenced by their work.

The first project will be estimating the amount of material required to fill a portion of a street on campus that has been undercut and is need of repair. Students can visit the site and collect data for the project. The problem is similar to the first activity in Starfield et al. [17] in which students estimate the number of ping pong balls that would fit in a classroom; however, the context of a collapsed street might seem more authentic to students in Track A, e.g., civil and mechanical engineering majors and to faculty members who will decide on whether to adopt the STEP approach for all engineering majors. The second project will be developing a model for estimating the time necessary to cool a can of beer in a refrigerator. The project will connect material to future work on heat transfer. The final project will be to model a spring-mass system. Spring-mass systems appear in many different contexts, e.g., earthquake-resistant buildings and automobile suspension systems and should appeal to Track A students and faculty members.

Assessment plans include the collection, analysis and reporting of first-to-second semester retention. Other elements of the assessment plan include:

- Analysis of progression within the engineering program in relation to Q drops for first semester students of STEP and non-STEP classes;
- An online perceptions survey for students in STEP and non-STEP classes at the beginning of the second semester, similar to that given at the end of the previous semester;
- Re-examination of second semester STEP to non-STEP group comparability in light of changes in class composition;
- Mid semester perception feedback from STEP class students on pedagogical innovations,
- Common problems and questions in engineering, math, and physics exams; and
- A summative post-perception survey of both STEP and non-STEP students near the close of the second semester.

In order to expand the STEP approach to Track B and C majors, faculty members will continue to search for projects that satisfy the projects specifications described above and increase the interests of Track B and C faculty members in the first-year engineering courses. In a complete implementation, students in different sections of the first-year engineering courses may be doing different projects, all of which meet the above specifications. Hopefully, a stream of projects can continue to be generated.

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Bibliographic Information

JO HOWZE
Jo Howze is Associate Dean for Engineering Academic Programs and Ford Professor of Electrical Engineering at Texas A&M University. He is Principal Investigator for the NSF STEPS program and is responsible for the Ford Motor Company sponsored effort to enhance "Design Across the Curriculum." His interests include distributed energy systems, control systems and engineering education, particularly interdisciplinary education and design.

JEFFREY FROYD
Jeffrey Froyd is a Research Professor in the Center for Teaching Excellence and Director of Academic Development at Texas A&M University. He was Project Director for the Foundation Coalition, one of the NSF Engineering

Education Coalitions and now serves as Project Director for "Changing Faculty through Learning Communities," a project sponsored by the NSF Research on Gender in Science and Engineering Program.

KRISTI J. SHYROCK
Kristi Shryock is a Project Manager in the Engineering Academic Programs Office at Texas A&M University. She received both a B.S. and M.S. in Aerospace Engineering from Texas A&M. Her interests include engineering education, MBTI, and learning styles.

ARUN R. SRINIVASA
Arun Srinivasa is an associate professor of Mechanical Engineering, Look College of Engineering, Texas A&M University. He received his Ph.D. in Mechanical Engineering from University of California, Berkeley in 1991. His interests include Continuum Mechanics, Dissipative phenomena and engineering education.

RITA CASO
Rita Caso, PhD - Deputy Director of TEES/TAMU Engineering Division of Academic Development and Director of the Educational Assessment Resources, provides outcomes assessment and program evaluation for this and several other educational initiative projects in Engineering and Science.