June, 1999

Introduction to Engineering Problem Solving—A New Course for 1100 First Year Engineering Students

Richard L. Porter, *North Carolina State University*
Laura J. Bottomley, *North Carolina State University*
Mary Clare Robbins, *North Carolina State University*
Walthea V. Yarbrough, *North Carolina State University*
Sarah A. Rajala, *North Carolina State University*, et al.

Introduction to Engineering Problem Solving - A New Course for 1100 First Year Engineering Students

Richard L. Porter, Laura J. Bottomley, Mary Clare Robbins, Walthea V. Yarbrough, Sarah A. Rajala, and Hugh Fuller
North Carolina State University

I. Introduction

During the past several years, NC State University has offered several experimental courses designed for the first year student in engineering; IMPEC, an integrated approach to mathematics, physics, engineering, and chemistry [1,2]; E123, a mechanical dissection course which is now linked with the first year writing and composition course [3,4]; and ECE 292D, a hands-on team based design course offered to upper class students as well [5,6]. All were offered as an alternative to the introductory course (E100) that had little academic content, no engineering problem solving, and consisted of a large lecture room format with information dissemination as the major goal. Although the alternate courses were excellent and well received by the students, none could be easily scaled up to accommodate 1100+ freshmen engineering students. In 1996 and again in 1997, a new version of freshmen engineering (E497F) was offered that incorporated many of the elements of the alternative courses [7]. This was offered to 250-350 engineering freshmen randomly selected each year.

Efforts are described to develop and deliver a freshmen engineering course for all 1100+ freshmen that incorporates most of the intrinsic features of the alternative courses; is firmly based on the ABET 2000 outcomes; stresses integration with other first year courses; and contains elements of written and oral communication, team building, critical thinking, multidisciplinary thinking, and problem solving. The structure of the course includes a weekly lecture in large groups, and a smaller team-based problem-solving laboratory which alternates with a required first year course focused on introduction to the computing environments on campus.

The content of the course, selection of topics, texts, and assignments is described. The other component of the course is the problem-solving laboratory facilitated by undergraduate student assistants. The laboratory component is strongly linked with the lecture and has a device-dissection component as well as a project design competition. Incorporation of a meaningful hands-on experience for all students presented a considerable challenge. Facilitation of the laboratory is discussed and the device-dissection component is described in another paper [8]. Students' attitudes about engineering and the entire first year experience were assessed using the Pittsburgh Freshman Engineering Attitudes Survey © (PFEAS) [9,10,11].

II. Course Design

Based upon lessons learned from other experimental courses[1-7], a first year course for all freshmen engineering students was designed and implemented. To do so, it was first necessary to identify desired outcomes, the content that would allow achievement of goals, the structure of the course, and the tactics necessary to achieve the outcomes. The outcomes specified in the ABET 2000 criteria were considered as basic objectives and all instructors of the experimental courses were asked to identify techniques to meet those outcomes, the structure used, and tactics employed. A matrix was constructed and used to rate each course and each instructional portion of the courses. This matrix approach allowed identification of those subjects and outcomes that had been positively assessed in all courses using the PFEAS as well as other internal assessment instruments. The identified contents are listed in Table 1 and the delivery methodologies in Table 2. Considerable experience was also obtained with the 1996 and 1997 offering of E497F, although a laboratory component was not specifically a part of those courses, which offered considerable assessment data[7].

Table 1. Identified Contents of the New Course

engineering problem solving	decision making
ability to apply math and science	oral communication
data analysis and interpretation	written communication
multidisciplinary teamwork	critical thinking
probability and statistics	contemporary issues
safety	societal impact
ethics	ability to apply computing skills
experimental design	system design
study skills	time management skills
research skills	library/web skills
choosing a major	broader view of engineering
individual vs. team learning	modeling

Table 2. Identified Delivery Methodologies

cooperative learning/collaboration	hands-on learning
active learning	open-ended thinking
project-oriented	lecturing
integration of fundamentals with engineering problems	integration of communications with problem solving
integration of different engineering disciplines	integration of computing skills with problem solving
critical thinking	high professor/student interaction
communication oriented	

Based on previous experiences with all freshmen engineering courses, it was decided that a text would be essential. The college publishes a handbook for freshmen which contains curricular issues, academic policies, some departmental information, matriculation policies, student professional organizations, tutoring, and other student services, but lacks academic content. A

text with content as described in the Table 1 was desired, and a custom published version of Eide[12] was chosen containing chapters 1-7. Because technical communication was also a desired component, a separate text in technical communication was also selected[13].

III. Course Structure

The "normal" first semester academic load for engineering students is Calculus I (MA 141), Chemistry (CH101) and laboratory, Composition and Rhetoric (ENG 111), Orientation to Engineering (E100), Introduction to Computing Environments (E115), and a humanities or social science elective. The E115 course is designed to acquaint students with the distributed UNIX based computing system and its capabilities and is a prerequisite for the computer programming course, either FORTRAN or C++, usually taken during the spring semester. In addition, NC State has several PC based laboratories including two specifically organized for this new course. The Orientation to Engineering course carries zero credits, but it was decided to use it as the framework for this new course. To the extent possible, the existing E115 course taken by all freshmen engineers was integrated into the new course. Thus formed, this new course, E497F, stresses contact, team work, writing, integration with the concurrent freshmen computer literacy course, and problem solving strategies, in addition to the "normal" content covered in E100. One goal was to inculcate engineering problem solving strategies while allowing students to inductively discover the approach used by various engineering disciplines.

The structure for E497F was based on the large lecture format used in E100 (six sections per week; 175-190 students per section) with an added laboratory limited to 48 students. The laboratory alternated with the E115 computing class. In any given week, approximately one half of the students were in E115 and the other half in the laboratory. Each lecture section was assigned one faculty member and the laboratories had two undergraduate teaching assistants each (selection and responsibilities are described below). The course carried one credit hour and was letter graded. The lecture component (including homework, journal, attendance, information sessions) was worth 40% of the grade while the laboratory was worth 60%. Group work was encouraged and, in fact, required for most of the laboratory assignments.

As much as possible, all topics covered were presented in an integrated fashion. Rather than simply lecturing on statistics, in class exercises were conducted which allowed discussion of experimental design, data analyses, modeling, and other related disciplinary information. An example is the paper clip failure experiment. Each student in class was given two paper clips. One half of the class flexed the clips at a straight section until failure, and the other half flexed them at a previously bent section. All data were collected and displayed as well as sent electronically to all students. The data were used immediately by the students for data presentation and graphing exercises as well as discussions of experimental design. The sections on Monday used a paper clip from a different supplier than did the Wednesday sections. The different manufacturers (and likely different alloys) were obvious as the students plotted the data. The variability led to discussions of reliability, ethics, and safety. Later in the semester, the same data were used for more detailed statistical analyses and presentations.

The intention was to make it obvious to the students that this class required total participation ; brainstorming sessions, team projects, in-class team work, modeling exercises, discussion of homework, and discussions of the assigned computer problems were commonplace. Students were required to maintain a journal containing all homework assignments, discussions, and comments on assigned readings. Although some lecturing occurred in the class, it was minimized and team based problems were chosen to illustrate the intended points. Some

"lecturing" topics included learning and teaching styles, study strategies, approaches to learning, cooperative and collaborative learning techniques, time and stress management, and tips for test takers. As a replacement for lectures on different engineering disciplines, the in-class discussions were designed to allow students to *discover* the responsibilities of various types of engineers.

In-class presentations by outside faculty and/or student services were minimized with the exception of Co-Op, Study Abroad, and the Career Center in an effort to minimize the "talking-head" visitations that usually had little or no connection with the remainder of the course. However, some class presentations were used as the basis for other discussions. For example, the faculty from the Civil Engineering robotics laboratory discussed materials selection and equipment design for a lunar mining operation. This was a basis for discussion on project work, technical presentations, evaluations, data analysis, etc. Another presentation was from a student group working on the HELIOS robot project that emphasized a multidisciplinary approach to a very difficult and complex engineering problem: placing a habitat efficiently in a lunar environment. In all cases, the presentations were turned into inductive approaches to problem solving. Students were asked to brainstorm in small groups, and, in some cases, provide answers to portions of the problems. Later in the semester, a professional engineering consultant (electrical engineering background and chemical industry experience) led a discussion on electrical safety including physiological effects of electricity, industrial design considerations, materials selection, ethics, and basic electrical power considerations. In teams, students were asked to brainstorm solutions to engineering problems common in space station design, industrial design, and manufacturing.

IV. Laboratory Component

A hands-on problem solving laboratory was developed to accompany the course. The laboratory component of the course was greatly enhanced by the donation of computer equipment from the Hewlett-Packard Company and the availability of a hands-on mechanical dissection laboratory used in one of the alternate courses[8]. The computer laboratories were designed to encourage group work: the laboratory tables were hexagonal with four computer units and eight chairs thereby requiring students to work in teams of two, as a minimum. In each of the problem solving sessions, students worked in teams and they were challenged to solve multidisciplinary engineering problems using various levels of mathematics and science, to complete a device dissection exercise, and to complete and present a design project. For each assignment, they were required to communicate their findings in a written report. For the design competition, peer evaluations were used and an oral presentation was required.

Student Engineering Leaders (SELs)

Early in the planning, it was decided to utilize undergraduates as teaching assistants for all the laboratory sessions. Identified characteristics included well rounded students with solid academic achievements, demonstrated histories of leadership, ability to function as mentors, and a willingness to work hard. It was also decided to direct recruitment to women engineers, all underrepresented minorities in the college, and the 350 students who had taken the experimental course the year before. All groups were notified via e-mail to apply by submitting their resume, including a description of their academic experiences, leadership experiences, work experiences, computing experiences, knowledge of UNIX and NT, and other software packages. A minimum grade point average of 2.5 was specified as well as good overall academic standing. Over 80 students applied and 40 were selected as finalists.

The instructors reviewed all resumes and ranked the students in terms of the pre-established criteria. Fifteen students and three alternates were selected and one chosen as the student administrator for the laboratory sessions. All students were expected to contribute at least ten hours per week and were compensated at $1100 for the semester. The 10 hours per week included facilitating the laboratory sessions, holding office hours, grading laboratory reports, serving as consultants for the design projects, and attending weekly staff meetings. Prior to the start of the laboratory sessions, all SELs were required to attend an afternoon teaching effectiveness workshop modeled on one used at NC State for several years for graduate student teaching assistants.

IV. Laboratory Projects

The laboratory projects included ice-breaker exercises, spreadsheet utilization, memo writing, and two engineering related projects dealing with cellular telephony and chemical reactor design, and the final design project. All students completed a two week rotation in the device dissection laboratory as well. The first project chosen was one used by Karl Smith[14] in which students must specify the minimum wire diameter to suspend a typical American automobile. At the conclusion of the laboratory, student teams were required to submit a technical memorandum with their recommendations.

The other projects required more in depth analyses and more mathematical skills as well as graphical presentation. The cellular telephony project required a graphical solution to placement of cellular telephone antennae towers surrounding a municipality with ordinances against placement within city limits. Students were to place the towers, determine the manner of illumination, calculate the number of clients served for the frequency bandwidth given, determine a signal to noise ratio, and evaluate the entire system. The second project required optimization of temperature for a simple constant stirred tank reactor (CSTR) with additional constraints imposed such as previous corrosion of the tank reactor and possible toxicity for given temperature regimes. Each project required a formal laboratory report complete with imbedded graphics, data analyses, spreadsheets, graphs, and proper format. These were graded by the engineering student leaders.

V. Design Projects

The design projects were intended to provide a team based opportunity for students to solve an engineering problem in a creative manner. Four projects were identified spanning several areas of engineering and computer science: bridge design, catapult design, web page design, and battery powered device design. The projects required more than the simple construction of a device or web page including an engineering solution, evaluation, calculations, final report, and a team based presentation. The presentations were peer reviewed by the entire laboratory section (typically 40-45 students). Students organized teams of four students and were given 4-5 weeks to complete the projects. A brief summary of the guidelines presented to the students is given below.

• Bridge - the bridge should be non-metallic and should be constructed from Balsa wood and/or pasta, rest on two supports placed 24 inches apart, and must span the distance between the supports. The bridge that holds the most weight relative to its weight will be judged the winner.

• Catapult - The catapult should be designed to throw one large marshmallow. Although the power of the catapult is at the discretion of the builder, the catapult design will be judged using the following criteria: weight of the catapult, distance object is projected, and accuracy of a

mathematical prediction. The winning catapult design will be the one that propels the object the farthest, is the lightest in weight, and is most true to its mathematical prediction.
• Web Page Design - Create a Web page for the E497F class. The winning page may be used as the E497F homepage. The purpose of this page is to inform visitors about the Introduction to Engineering course. It should identify the subject matter included in the course, it should describe the laboratory component, and the grading for the course. The page should be interesting and should hold visitor's attention. Each project must include a mathematical analysis and prediction for access time from a specified machine. The winning page will include a variety of special effects and content, e.g., backgrounds, images, animated gifs, links to other appropriate pages, client-side image maps, Javascript, etc.
• Battery Operated Device - Develop a battery-operated device that addresses one of the following categories: quality-of-life improvement, improvement in education, commercial value and/or entertainment. The device should be portable, self-contained, and able to operate independently of other supplementary equipment, should not interface with any line-powered device(s), and is restricted to alkaline AAA, AA, C, D, 9-volt, and/or lantern batteries. Each project should include a mathematical model that calculates the lifetime of the device and the power consumption.

The bridge and catapult design presented formidable challenges in several ways. Students do not have access to workshop areas so a supply of basic tools, saws, glue guns, scales, measuring devices, were provided that could be checked out for two day periods. The battery operated device was not a popular choice for several reasons but foremost because it was open-ended and students had little experience with electrical design in high school or in the first few months of the semester (in fact, only four groups chose to submit a battery operated device project). The bridge design and web design were the most popular likely due to familiarity and popularity of bridge design contests in high schools and very high student confidence in using the web and other related software.

The bridges were tested after their presentations using loads of bricks and those not breaking were taken to the Civil Engineering department for further testing. Catapult designs were tested in class or outdoors depending upon the design. All web pages were reviewed by the laboratory instructors and submitted to the faculty for consideration. Although several designs for catapults and bridges were innovative and powerful and/or strong, they had to meet the criteria specified. One catapult in particular predicted a 105 foot distance with a marshmallow velocity of 56 ft/sec., and was indeed quite accurate but lost points for its extremely large size (weight). The winning catapult weighed 8 oz. and tossed a marshmallow 55 feet with excellent reproducibility. The winning bridge was aptly named Occam's Razor and was able to withstand a load of 2000 lb while weighing only 42.5 oz. This was simply a hardwood 2"x4" wrapped with duct tape. The next best bridge weighed 9 oz. and held 175 lb prior to failure. Of the four battery operated devices, one was selected as a winner and in fact was a battery controlled catapult.

VI. Assessment

In addition to the Pittsburgh Freshmen Engineering Attitudes Survey [9,10, 11], a separate survey was administered at the end of the course. This survey was designed to assess student evaluations of each component of the course. A Likert scale was used, with 1= strongly disagree and 5= strongly agree. A summary of the 830 responses is given in Table 3.

The old introductory course was based on in-class presentations from most of the engineering departments, student services (career center, study abroad, academic integrity), and the co-op program. Interest was never very high and it created the "talking heads" reputation for the class. In the new class, departments were not included for in-class presentations but each held several out of class sessions designed to give students having interest in that department more in depth information and an opportunity to tour facilities, talk with faculty, graduate students, and undergraduates in the department. All students were required to attend at least two outside of class departmental information sessions. The in-class presentations were all designed to stress the interdependency of engineering disciplines, the creative nature of engineering, and the approaches to problem solving especially in a multidisciplinary team.

Table 3. Student Assessment of the Lecture Component

question	mean	% "disagree" and "strongly disagree"	% neutral	% "agree" and "strongly agree"
the in-class presentations were helpful in gaining an understanding about the nature of engineering	3.67	15.3%	14.0%	70.6
the departmental information sessions presented useful information	3.30	25.6	22.2	52.2
I understand the value of keeping an engineering journal	2.84	39.6	28.0	32.4
the class helped me see the links between engineering, math, chemistry, physics, and computer science	3.42	18.4	23.1	58.4
the course helped me understand what to expect from my academic adviser	3.31	22.6	26.0	51.3

The attempt to incorporate required journals was not very successful. Sufficient challenges and requirements as well as timely collection of the journals and feedback throughout the semester did not make it clear as to the importance of writing and maintaining a journal in engineering education. However, assessment of the previous offering of E497F to 350 students indicated a greater student confidence in writing than those students in the normal E100. The value in the table above related to journals was not as high as the previous offerings but indeed higher than the previous E100 course[7]. An effort has been put into place specifically to increase this activity and will be assisted by the campus technical writing center. The last two questions were specific outcomes that were successful.

Student attitudes concerning each component of the laboratory sessions were also assessed. A summary of the responses is given in Table 4. Each component was rated with regard to the extent to which it helped gain a better knowledge about engineering. Both the cellular telephony and the chemical reactor design laboratories were team-based in-class projects. Each required the use of a spreadsheet and some simple mathematical analyses. The low student satisfaction with all assessed components of the laboratory except for the design project was not expected. The design projects were quite open-ended and required considerable more effort than the others. It is apparent that the proper connections to engineering were not made, in general, for the other components of the laboratory and the students viewed them as additional homework, whereas the design project allowed creativity as well as individual accountability.

VII. Lessons Learned

It was anticipated that each student would simply follow their schedules and instructions given in class and attend all the laboratory sessions, mechanical dissection laboratory, classes, and departmental information sessions. All students were preregistered during the summer for the course and its laboratory. Due to the structure of the course and the fact that the laboratory sections were piggybacked into a time slot alternating with another required computing class, and the fact that several students decided to alter their schedules for convenience, there was considerable confusion early in the semester. At the end of the third week of class, most schedules had been corrected and the students settled into their laboratories. Organizational management is essential in dealing with 1100 students with six different lectures, 15 lab sections, three different locations, and alternating with another class.

Table 4. Student Assessment of the Laboratory

question	mean	% "disagree" and "strongly disagree"	% neutral	% "agree" and "strongly agree"
mechanical dissection "take-apart" laboratory	2.99	34.2%	25.2	40.4%
cellular telephony laboratory	2.94	34.4	29.4	36.3
chemical reactor design laboratory	2.97	33.0	31.1	35.9
engineering design project contest	3.63	17.0	17.4	65.4
overall, the laboratory was enjoyable	3.05	32.9	26.7	40.3

More importantly, utilization of undergraduates as student leaders in the laboratory is an excellent use of very talented students and provided for a tremendous mentoring arrangement, but requires considerable preparation and a strong organizational structure in providing needed resources and information well ahead of time. Although all but one of the student leaders said they would do it again, they were critical of many of the little problems that professors face daily such as students not attending, equipment broken, scheduling errors, student apathy or disinterest in the laboratory. We found that the use of a lesson plan developed early and presented to the student leaders at least one or more weeks prior to the class essential. Undergraduates students used as teaching assistants need to be shown more directly than a simple workshop how to lead teams, to encourage creative solutions, to ask questions, and to function effectively in a laboratory.

One of the major problems with the laboratory was that most of the undergraduate teaching assistants had not been enrolled in the experimental course the year before and therefore had not attempted most of the problems and had a low degree of confidence in the assigned problems. Most of the undergraduate assistants were uncomfortable in a team based cooperative-learning environment and this will be addressed before the next offering. Student assistants for the fall will be selected early in the spring semester and required to attend several workshops throughout the semester. A laboratory manual/teaching guide will also be developed during the spring semester. This will serve two purposes: a laboratory manual to be distributed to all students and a teaching manual with solutions, suggested approaches, and ideas for brainstorming exercises and other laboratory activities. This effort will be directed by the faculty involved, some of the experienced undergraduate assistants, and a writing consultant from the Center for Technical Communications.

VIII. Plans for The Future

The new course will be offered in the Fall of 1999 to all new freshmen engineering students (1100). A more intensive workshop for the engineering student leaders will be implemented. A laboratory manual, including lesson plans, suggested group activities, and technical background for all activities will be developed in the spring semester using some of the experienced ESLs and with assistance from the technical writing staff at the university. Several new design projects will be offered and offered much earlier in the semester.

Acknowledgments

Partial funding was provided by SUCCEED, a NSF Engineering Education Coalition Program, the College of Engineering at NC State, Hewlett-Packard Company, and the Office of the Provost, NC State University.

Bibliography

1. Felder, R. M., Bernold, L. E., Burniston, E. E., Gastineau, J. E., and O'Neal, J. B., "An Integrated First-Year Engineering Curriculum at North Carolina State University," 1995 Frontiers in Education Conference Proceedings, Atlanta, GA, November 1995.
2. Felder, R.M., Beichner, R.J., Bernold, L.E., Burniston, E.E., Dail, P.R., "Update on IMPEC," presented at 1997 ASEE Annual Conference, Milwaukee, WI, June, 1997.
3. Beaudoin, D. L., and Ollis, D. F., "A Product and Process Engineerng Laboratory for Freshmen," Journal of Engineering Education, Vol. 84 [4], 1995, pp.1-6.
4. Brown, A., and Ollis, D. F., "Team Teaching: A Freshmen Engineering Rhetoric and Laboratory," ASEE 1996 Annual Conference Proceesings, Washington, DC, June 1996.
5. Sutton, J. and Brickley, J.J., "A Course in Engineering Skills and Design for Freshmen and Rising Sophomores," 1995 Frontiers in Education Conference Proceedings, Atlanta, GA, November 1995.
6. Conrad, J.M. and Brickley, J.J., "Using Stiquito in an Introduction to Engineering Skills and Design Course," 1997 Frontiers in Education Conference Proceedings, Pittsburgh, PA, November 1997, paper 1180.
7. Porter, R. L., and Fuller, H., "A New Contact Based First Year Engineering Course," Journal of Engineering Education, Vol. 87 (4), 1998, pp. 399-404.
8. Ollis, D.F., Kondratowicz, D., "A Device Dissection for Eleven Hundred Engineering Students," *Preceedings, 1999 ASEE Annual Conference*, ASEE, 1999.
9. Besterfield-Sacre, M. E., and Atman, C. J., "Survey Design Methodology: Measuring Freshman Attitudes About Engineering," ASEE 1994 *Annual Conference Proceedings*, Edmonton, Alberta, June 26-29, 1994.
10. Besterfield-Sacre, M.E., Atman, C.J., Shuman, L.J., "How Freshman Attitudes Change in The First Year," ASEE 1995 *Annual Conference Proceesings*, June 1995, Anaheim, CA, pp. 157-163.
11. Besterfield-Sacre, M. E., Atman, C. J., Shuman, L. J., "Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering," Journal of Engineering Education, Vol. 86 [2], 1997, pp. 139-150.
12. Eide, A.R., Jenison, R.D., Mashaw, L. H., and Northup, L.L., *Engineering Fundamentals and Problem Solving*, 3rd Edition, Selected Chapters, McGraw-Hill, Primus Custom Publishing, New York, 1998.
13. Eisenberg, A., *A Beginner's Guide to Technical Communication*, WCB McGraw-Hill, New York, 1998
14. Smith, K. A., adapted from Adams, J. L., *Flying Buttresses, Entropy, and O-Rings: The World of an Engineer*, Harvard University Press, Cambridge, MA, 1991.

RICHARD L. PORTER
Richard Porter is the Assistant Dean for Academic Affairs at North Carolina State University. He received his B.S. and M.S. in Ceramic Science from Alfred University, and his Ph.D. in Materials Science from McMaster University. His areas of interest and responsibility include freshman orientation courses, student development and retention, advising, assessment, gendered communications, international programs, and integration of the humanities and social sciences with engineering curricula. He is co-director of the Franklin Scholars Program which is a dual degree program between the Colleges of Engineering and Humanities and Social Sciences. He has been named as an Outstanding Teacher, Outstanding Adviser, and Alumni Distinguished Professor.

LAURA J. BOTTOMLEY
Laura Bottomley is the Coordinator of the Women in Engineering Program at NC State University and an Adjunct Professor of Electrical and Computer Engineering. She has a B.S. and M.S. in Electrical Engineering from VA Tech and a Ph.D. in Electrical Engineering from NC State University. She has worked at AT&T Bell Laboratories and at Duke University as a research assistant professor. She advises engineering students and co-teaches the First Year Introduction to Engineering course in addition to managing the Women in Engineering Program.

MARY CLARE ROBBINS
Mary Clare Robbins is the Coordinator of the Engineering Undesignated Program at North Carolina State University and holds the rank of Lecturer in the College of Engineering. She has a Bachelor of Science in Psychology from Duke University, and a B.S., M.M.E., and Ph. D. in Mechanical Engineering from NC State University. Her responsibilities include advising students and coordinating advising activities as well as co-teaching the First Year Introduction to Engineering Course. In addition, she manages matriculation procedures for the College of Engineering.

WALTHEA V. YARBROUGH
Walthea V. Yarbrough is the Assistant Coordinator of the Engineering Undesignated Program at North Carolina State University and a lecturer in the Department of Industrial Engineering. In addition to advising engineering undesignated students, she participates in teaching the Introduction to Engineering class and coordinates a program for students on academic warning. Dr. Yarbrough earned B.S and M.S. degrees in Industrial Engineering from North Carolina Agricultural and Technical State University (in 1989 and 1991, respectively) and a Ph. D. in Industrial and Systems Engineering from Virginia Polytechnic Institute and State University in 1994.

HUGH FULLER
Hugh Fuller is Director of Educational Assessment for the College of Engineering at NC State University. He received his B.A. from Clemson University, and a M.A. in English and Ed.D. in Higher Education Administration from North Carolina State University. He has served as Director of Institutional Research and Director of the Academic Skills Program at NC State University.