

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ABET Criterion 3: Program Outcomes

1. To demonstrate that graduates have an ability to apply knowledge of mathematics, science, and engineering, they should:

- show that they can employ general principles, theories, concepts, and/or formulas from mathematics, science, and engineering in the solution of problems in their field of engineering. For a particular problem, graduates should demonstrate that they can:
 - (1) define and describe the pertinent principle, theory, concept, and/or formula;
 - (2) explain why it is appropriate to the problem; and
 - (3) demonstrate how it has been applied in the solution of the problem.
- respond favorably, after they have been on the job, to the instruction and guidance they received at NC State in applying knowledge of mathematics, science, and engineering to the particular engineering problems they encounter at work;
- achieve a favorable rating from their employers regarding their ability to apply general principles of mathematics, science, and engineering to particular engineering situations.

Evidence for Assessment

Portfolios: Samples from homework and/or tests in which students apply their knowledge of mathematics, science, and engineering to problem sets, showing that they can do so following the above three steps.

Survey question for graduates: My education at NC State has given me the ability and the confidence to apply general principles of mathematics, science, and engineering to the engineering problems I encounter at work.

Survey question for employers: The NC State graduate is entirely satisfactory in his or her ability to apply general principles of mathematics, science, and engineering to engineering problems.

2. To demonstrate that graduates have an ability to conduct experiments and analyze and interpret data, they should:

- show that they can conduct an experimental procedure, use laboratory materials properly and safely, carefully note observations in a laboratory notebook, and describe the procedure clearly for others;
- show that they can measure and record raw experimental data and analyze those data for the purposes of understanding and explaining the data. Graduates should be able to represent data in both verbal and visual forms (equations, tables, graphs, figures, etc.) in a way that is both an accurate and an honest reflection of the data.

- show that they can render the data meaningful by discussing the data in the context of the hypothesis and appropriate theories and principles and by stating, clearly and concisely, conclusions that can be drawn from the experiment.

Evidence for Assessment

Portfolios: Laboratory notebooks and reports in which students demonstrate their ability to conduct experiments and analyze and interpret data.

3. To demonstrate that graduates have an ability to design a system, component, or process to meet desired needs, they should:

- show that they can engage productively and creatively in the process of design. Design is a multi-dimensional act that requires a balance of opposing characteristics: divergent and convergent thinking, synthesis and analysis, aesthetic and utilitarian sensibilities. The process itself is flexible and recursive; that is, designers often find it necessary to skip around among the different phases of the process. It is helpful to think of the design process as defined by the following phases:
 - establishing the goal of the design project, the outcome that must be attained;
 - defining the project. This phase consists of identifying the criteria for the outcome and the parameters for the project. The criteria are a reflection of the desired needs that the project must meet, the standards against which the success of the outcome will be measured. The parameters are the boundaries within which the designers must work, the materials available, the kinds of expertise that are appropriate, the limitations on cost and time, etc.;
 - brainstorming for alternative possibilities. These may be possibilities for achieving the outcome of the project or possibilities for finding solutions to immediate problems that come up during the process;
 - choosing the best of the possible solutions. This part of the process involves matching possible solutions to criteria. These may be criteria for the outcome of the project established formally earlier in the project or criteria developed informally for more immediate problems;
 - creating a prototype or model that embodies or represents the chosen solution;
 - testing the prototype or model against the criteria for the project. The results of this testing may send the designers back to any of the above stages;
 - choosing and justifying to an appropriate audience the final system, component, or process. Both choosing and justifying must be done in reference to the criteria spelled out for the project outcome.
- respond favorably, after they have been on the job, to the training and guidance in design process they received at NC State;
- achieve a favorable rating from their employers regarding their ability to engage productively and creatively in the process of design.

Evidence for Assessment

Portfolios: Final technical reports and other reports and documents related to a design project. Included with these reports and documents will be students' design logs for each project, in which the students describe their design work according to the above components of the design process.

Video-tapes: Examples of students' design day presentations.

Survey question for graduates: The training and practice I received at NC State has been very helpful to me in engineering design projects.

Survey question for employers: The NC State graduate performs productively and creatively in engineering design projects.

4. To demonstrate that graduates have an ability to function on teams, they must:

- possess a conceptual understanding of group dynamics, that is, how to make groups work effectively. This conceptual understanding includes:
 - (1) how to create a group climate that encourages success,
 - (2) how to recognize and make effective use of power resources in group activities, and
 - (3) how to use communication strategies for dealing productively with conflict.
- show that they can participate effectively as team members in long-term group projects: working cooperatively with others, accepting divergent views, encouraging active participation of others, dealing productively with conflict, and taking leadership roles as the need arises to accomplish the group's objective;
- show that they can work successfully with people who are in other fields and those who perform a variety of functions within a group. This means that they must:
 - (1) exhibit respect for these people and the diversity they bring to the group,
 - (2) accept and incorporate, where appropriate, ideas from people with different perspectives; and
 - (3) explain pertinent engineering principles and applications to people who have no training in those principles and applications but who need to make use of them.
- report, upon graduation, positive experiences related to the work they have done in teams. And if those experiences have been negative they should show that they know what they could have done to make their teams work more productively;
- respond favorably, after they have been on the job, to the training and guidance they received at NC State in working in teams;
- achieve a favorable rating from their employers regarding their ability to work effectively in multi-disciplinary teams.

Evidence for Assessment

Peer evaluations: A collection of students' assessment of their team members and their teamwork experience to be turned in after group projects and at the mid-point as well as the end of extended group projects.

Senior exit interviews: Students will be asked questions about their teamwork experiences in their courses: whether those experiences were positive or negative, what they learned from the experiences about the skills and strategies they could employ to make group work successful, what they know about the conceptual understanding of group dynamics, and their impressions of the instruction and guidance in teamwork they received from their professors.

Survey question for graduates: My experience at NC State prepared me to work effectively on teams.

Survey question for employers: The NC State graduate is an effective and productive team member who knows how to make a team successful.

5. To demonstrate that graduates have an ability to define, formulate, and solve engineering problems, they should:

- show that they can define an engineering problem. Defining a problem means asking certain strategic questions about a problem in order to make it more solvable. Such questions may include: Is there sufficient information to solve the problem, and if not what else do I need to know and how do I find it? Is there extraneous information pertaining to the problem that I can dismiss? Are there any items in the problem that could be better understood by quantifying them? What are the key terms of the problem and how they be defined?
- show that they can analyze problems, that is, isolate and describe the important components of a problem: what is given (design specifications, availability of materials, performance requirements, testing standards, etc.); what is known from previous experience relevant to the problem (including information from a search of the pertinent engineering literature, patents, standards, etc.); and what the unknowns are;
- show that they can represent a problem in a form that makes finding solutions more efficient and effective. Such representations are typically visual, such as a model, flow chart, diagram, or table. This visualization should represent the components of the problem in a way that leads to the construction of a solution.
- show that they can apply engineering principles and mathematics to find the unknowns and arrive at appropriate solutions to the problem;
- respond favorably, after they have been on the job, to the training and guidance they received at NC State in solving engineering problems;
- achieve a favorable rating from their employers regarding their ability to solve engineering problems.

Evidence for Assessment

Portfolios: Samples of problem sets and students' brainstorming notes from homework and/or tests in which students show their ability to creatively solve engineering problems. These samples should exhibit students' proficiency at defining, analyzing, representing, and finding solutions to problems.

Survey question for graduates: The training and guidance in problem solving I received at NC State has been helpful in identifying, formulating, and solving engineering problems on the job.

Survey question for employers: The NC State graduate is good at identifying, formulating, and solving engineering problems on the job.

6. To demonstrate that graduates have an understanding of professional and ethical responsibility, they should:

- show that they can apply an understanding of ethical and professional responsibility, including safety and environmental issues, to an engineering situation that is ethically and professionally ambiguous.
- respond favorably, after they have been on the job, to the preparation in professional and ethical responsibility they received at NC State;
- achieve a favorable rating from their employers regarding their professional and ethical responsibility.

Evidence for Assessment

Portfolios: Samples of papers or presentations in which students present a case that is ethically and professionally ambiguous. The students should show that they can reason through the relevant ethical and professional issues and make arguments for maintaining the optimal balance between the contending forces of utility, cost, and risks.

Survey question for graduates: My engineering education at NC State was beneficial in helping me to develop a solid understanding of the professional and ethical responsibilities of an engineer.

Survey question for employers: I would describe the NC State graduate as exhibiting a high degree of professional and ethical responsibility in his or her work as an engineer.

7. To show that graduates have an ability to communicate effectively, they should:

- exhibit a mastery of the forms of discourse appropriate to the profession of engineering: laboratory report, oral and written progress report, technical report, technical presentation, etc. Depending on the form that is used, students should demonstrate that they can:
 - (1) describe the context (institutional and/or technological) of a problem and the significance of that problem within that context (introduction);
 - (2) describe clearly and precisely the procedures used to solve the problem (methods);
 - (3) report both verbally and visually the findings (results);
 - (4) interpret the findings in a way that is appropriate to the audience (discussion); and

(5) propose recommendations for a solution to the problem and justify that solution persuasively (conclusion).

- show that they can summarize technical material in way that is appropriate to a particular audience. Graduates should demonstrate that they can synthesize their own work and the work of others in the form of abstracts, executive summaries, and literature surveys.
- show that they can communicate successfully for obtaining and maintaining productive employment. For getting employment, graduates should show that they can write résumés and letters of application and perform capably in a job interview situation. For maintaining employment, graduates should show that they can write competent memos, letters, e-mail messages, proposals, and various reports (progress, personnel, maintenance, sales, trip, etc.) and give effective oral presentations to a variety of audiences.
- express confidence, upon graduation, of their ability to communicate effectively in their engineering careers;
- respond favorably, after they have been on the job, to the training and guidance they received at NC State in working in teams;
- achieve a favorable rating from their employers regarding their ability to work effectively in multi-disciplinary teams.

Evidence for Assessment

Portfolios: A collection of students' engineering reports, including lab reports, proposals, progress reports, and technical reports. Portfolio should include exhibits of students' ability to summarize technical material: abstract, executive summaries, and literature reviews.

Portfolios: Samples of documents showing that students can communicate successfully for obtaining and maintaining employment.

Video-tapes: Examples of students' design day presentations.

Senior exit interviews: Students will be asked questions about oral and written communication: how confident they are in their preparation to perform capably on the job, their understanding of the kinds of writing and speaking they will be asked to do as professional engineers, the quality of guidance and instruction they received in writing and speaking.

Survey question for graduates: What I learned at NC State prepared me well for the kinds of writing and speaking that I do at work.

Survey question for employers: I would give the NC State graduate a high rating on his or her ability to communicate effectively on the job.

8. To demonstrate that graduates have the broad education to understand the impact of engineering solutions in a global and societal context, they should:

- express satisfaction, upon graduation, that their education at NC State has helped them to understand the impact of engineering solutions in a global and societal context;
- respond favorably, after they have been on the job, to the broad education they received at NC State and the way it has helped them to understand the impact of engineering solutions in a global and societal context.

Evidence for Assessment

Senior exit interview: Seniors will be asked questions about their understanding of the global and societal context of engineering and the extent to which their education at NC State has contributed to that understanding. They will also be asked what recommendations they have for enhancing their education in a way that they could improve their understanding of the broader context of engineering.

Survey question for graduates: My educational experience at NC State, both formal and informal, helped me to develop a good understanding of the impact of engineering solutions in a global and societal context.

9. To demonstrate that graduates recognize the need for and possess the ability to engage in life-long learning, they should:

- show that they can use the critical information-seeking tools that enable engineers to continue to stay up to date in their profession: internet resources, engineering journals, US and foreign patent materials, standards, etc.
- show that as long as they continue to be employed as engineers, they are actively involved in the profession: membership in an engineering society, achievement and maintenance of technical registration for engineers, involvement in continuing education, etc.
- express, upon graduation, both a full appreciation for the need for and the motivation to pursue further education and training, both engineering and otherwise, over their lifetimes;
- show that after graduation they have continued to seek opportunities for further education and training, both engineering and otherwise.

Evidence for Assessment

Portfolios: Samples from homework or projects that demonstrate students' ability to use the information-seeking tools of engineering.

List of student members of IEEE: Percentage of students who have a membership in IEEE.

Senior exit interviews: Seniors will be asked about their perception of the value of life-long learning and their plans to pursue life-long learning related to their professional field--

membership in engineering societies, professional certification, graduate education, continuing education, etc.--and to their non-professional interests.

Survey question for graduates: Since my graduation from NC State I have continued to seek opportunities for further education and training to enhance my professional work and/or my life.

10. To demonstrate that graduates possess a knowledge of contemporary issues, they should:

- show that they have taken and performed adequately in a variety of university courses that are concerned with contemporary issues and/or the context for understanding those issues, including courses in the humanities, arts, and social sciences, and those that combine one or more fields of study, such as science, technology, and society;
- respond favorably, after they have been on the job, to the quality of education in contemporary issues they received at NC State.

Evidence for Assessment

Transcripts of graduates: Transcripts should show that graduates have taken a variety of courses concerned with contemporary issues and/or the context for understanding those issues.

Survey question for graduates: The courses I took at NC State have given me a good foundation for understanding the contemporary social, political, aesthetic, and technical issues that surround me.

11. To demonstrate that graduates have an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice, they should:

- show that they possess the skills of mathematical analysis and the ability to write programs and to use conventional bench testing equipment.
- show that they possess a working knowledge of a modern programming language and the ability to use various applications packages, such as Maple, Matlab, and SPICE. Students should also show that they understand the purposes and limitations of applications packages, when it is appropriate to use them and when it is not.

Evidence for Assessment

Portfolios: Samples from students' work that demonstrates their ability to use mathematical analysis and conventional bench testing equipment and write programs.

Computer files: Electronic copies of students' work that demonstrates their working knowledge of a modern programming language and their ability to use, appropriately and efficiently, applications packages, such as Maple, Matlab, and SPICE.