

Mid-Program Assessment
of
Team-Based
Engineering Design:
Concepts, Methods, and Materials

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Leadership for the TIDEE project has been provided by Denny C. Davis and Richard W. Crain Jr, from Washington State University, Dale E. Calkins from University of Washington, and Kenneth L. Gentili from Tacoma Community College. Michael S. Trevisan of Washington State University led the assessment efforts in the project. Steven Beyerlein of the University of Idaho, Donald Dewey of The Boeing Company, and John Selby of Weyerhaeuser Company have made additional contributions to this monograph. Susan Clausen and Cindy Sindayen contributed much to the compilation, typesetting, and printing of this monograph.

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DEDICATION

In August 1997, the untimely death of Richard W. Crain Jr. deprived the TIDEE project of Dick’s incredible creativity, energy, and experience in engineering education. It is to Dick Crain that this monograph is dedicated. This monograph exemplifies the type of contributions to engineering education that Dick has led and inspired.

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INTRODUCTION

As a “culture of accountability” emerges across America, assessment is gaining importance in the eyes of educators, policy makers, and the general public. People and organizations, wanting to ensure that desired learning is achieved, see assessment as a tool for documenting student achievement and for identifying strategies to improve student learning. Therefore, it is imperative that educators be knowledgeable about assessment concepts, be timely and skillful in administration of assessments and interpretation of their results, and be responsive in using assessment results to improve student learning.

Students’ abilities to solve problems, especially in collaboration with others, is a commonly expressed concern in society, particularly among technical disciplines such as engineering. Society’s increasing dependence on technology, and challenges posed by the sophistication and potential conflicts of technologies with social priorities, require that creative problem solving capabilities be broadly applied throughout society. Thus, for a society in a rapidly changing technological era, creative problem solving is a core competency.

Creative problem solving and engineering design are of great importance to the engineering profession, and therefore must be a focus for engineering educators. Criteria for engineering accreditation recently adopted by the Accreditation Board for Engineering and Technology (ABET)—referred to as Engineering Criteria 2000—require all engineering degree programs to demonstrate that their graduates can design and create solutions to engineering problems and can work effectively in multi-disciplinary teams¹. Therefore, engineering educators must not only be able to develop students’ team-based design capabilities, but also assess and provide evidence of these capabilities in graduates.

With dual assessment goals—to monitor student achievement and to guide program revisions for improving student learning—assessment of students’ capabilities must occur at multiple points in students’ academic journey toward an engineering degree. Both formative and summative assessments are required. The formative assessments guide in-process revisions, while summative assessments provide measures of program success.

A special challenge occurs in assessing design capabilities of students who transfer among institutions during their degree programs. During the first two years of an engineering curriculum, different institutions address design education using a variety of approaches— from

singular intensive design courses to design experiences distributed among a variety of courses. A mid-program design assessment offers engineering educators a number of potential benefits:

- (a) To determine and compare learning accomplished via different approaches,
- (b) To communicate to faculty at the supplier and receiver institutions a set of expected design education outcomes,
- (c) To determine readiness of a class for design, thereby showing receiving institutions what instructional levels are appropriate for effective learning and informing sending institutions about the adequacy of their educational programs to deliver expected design education outcomes.

This monograph focuses on assessment of team-based design capabilities at the mid-program level. (End-of-program assessments will be discussed in another monograph). It provides background on relevant instructional and assessment concepts, offers examples of useful assessment instruments, and guides educators through proper application of assessments.

OVERVIEW OF CONCEPTS

Engineering design is creative. Individuals and teams engaged in design perform actions that result in design products or solutions. Quality of the design products depends upon the capabilities (knowledge and skills) of the designers and the processes they utilize.

Types of Design Education Outcomes

When teaching and assessing engineering design, educators must distinguish among three types of learning outcomes:

- a. design **knowledge**,
- b. design **processes**, and
- c. design **products**.

Design knowledge includes students' understanding of design terminology, design concepts, and relationships among design actions and results. Design processes are the sequences of steps students utilize to create the desired design products. Design products are the items created as a result of the design activity— new materials, objects, components, systems, documents, or processes to meet specified needs. Another type of outcome, student attitudes, will not be addressed here except as attitudes are reflected in actions (part of processes).

Figure 1 illustrates a shifting educational balance among design knowledge, process, and product that should occur at different stages of an engineering degree program. First-year students need to gain foundational understanding of design terminology and concepts and to learn appropriate design processes. (Their knowledge provides a foundation for appropriate actions.) Although first-year students also will create design products, these are of minor concern at this point. Students in their mid-program years need to focus on refinement of design processes, while continuing to increase their design knowledge and giving more weight to design product quality. Students nearing completion of their engineering degrees should continue to improve their design processes, but they should focus on creating products that meet client requirements. For the most effective development of students' design capabilities, learning exercises at increasingly

advanced points in the curriculum should exhibit this shift in emphasis from knowledge and process toward product.

Types of Outcomes for Learning and Assessment

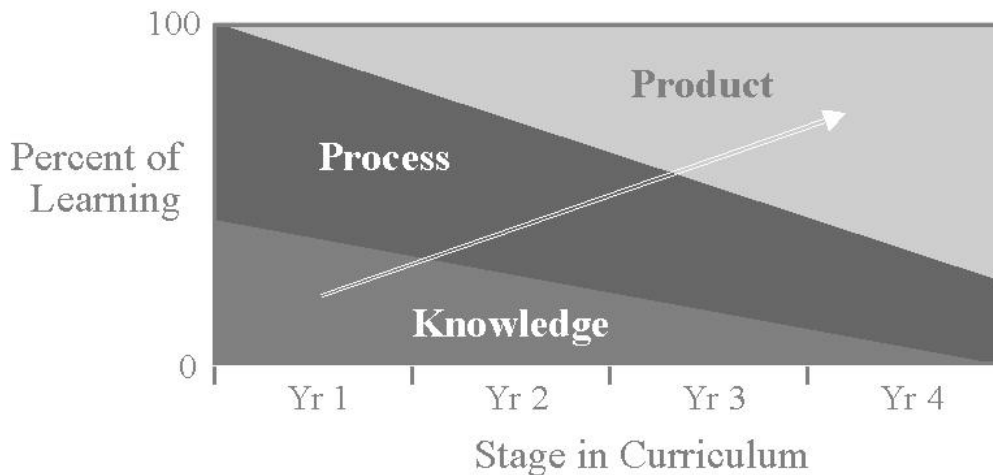


Figure 1. Shifting Educational Balance in Design Education Outcomes

Mid-program assessments of students' design capabilities should address the types of design outcomes being developed during the first two years of engineering curricula. Thus, mid-program assessments need to assess students' knowledge of team-based design concepts and their abilities to employ effective processes in the performance of team-based engineering design. Mid-program assessments should only minimally address quality of the design product.

Assessment and Learning

Mid-program assessment is a means of obtaining student performance data that can guide improvement of a curriculum and the associated student learning. Figure 2 illustrates the cycle envisioned for assessing student learning and using assessment results to inform revisions to curriculum and teaching methods.

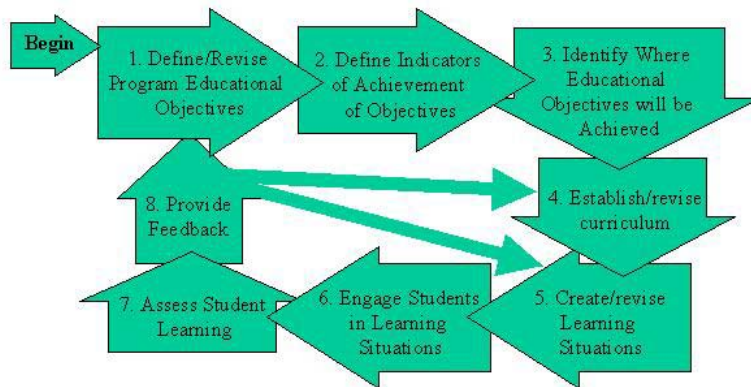


Figure 2. Process for Improvement of Learning

The steps in the assessment and learning cycle are discussed below.

1. Define/Revise Program Educational Objectives

Program educational objectives define the set of educational outcomes expected of graduates. These need to be established with input from relevant constituencies and be reviewed periodically to ensure their responsiveness to changing needs¹. From program educational objectives, mid-program educational objectives need to be derived to provide the target for educational programming during the first half of the curriculum.

2. Define Indicators of Achievement of Objectives

Performance indicators define observable performance attributes that distinguish among different levels of achievement of the established educational objectives. When multiple dimensions of these performance indicators are defined, a scoring scale must be defined for each performance dimension or criterion. For example, when teamwork indicators include dimensions of organization, team unity, and utilization of resources, descriptors of exemplary to poor performance in each are required to define indicators of achievement in teamwork.

3. Identify Where Educational Objectives Will be Achieved

Educational objectives are achieved reliably when they are linked strategically to required parts of a student's academic program. Thus, for each educational objective, one or more courses,

laboratories, field trips, projects, work experiences, or other mandatory parts of a degree program must be clearly identified as a part of the process for achieving this objective. This establishes one of the objectives for the linked educational experiences, and it supports assessment and improvement of the experiences to enhance the targeted learning.

4. Establish/Revise Curriculum

The curriculum is the formal plan for achieving the educational objectives of the degree program. Thus, the curriculum includes the (frequently ordered) set of courses, laboratories, field trips, etc. that provide the educational experiences required as educational inputs to achieve the educational objectives. If all educational objectives are not adequately addressed, or they are addressed in an unbalanced fashion, revisions are required to align the curriculum with the educational objectives.

5. Create/Revise Learning Situations

Learning situations are opportunities designed to help students achieve desired learning. These include class lectures, problem sets, group discussions, team projects, term papers, laboratory experiments, and other activities to guide student learning. Once educational objectives have been linked to parts of the curriculum, a plan is required to structure students' actions and interactions with information to yield targeted knowledge, process, and product educational outcomes. Studying and critical thinking beget cognition (knowledge), practice produces skill (process) development, and use of design processes yield design products.

6. Engage Students in Learning Situations

The implementation of learning strategies engages students in situations that support targeted learning. With varying effectiveness, these events give students opportunities to learn, but the events do not ensure learning. Factors influencing learning include: student motivation, time invested in learning, number of senses utilized in exercises, guidance of the instructor, match of instructional techniques to students' preferred learning styles, etc. Instructors who manage learning situations well can improve learning.

7. Assess Student Learning

Assessment of student learning includes obtaining data with respect to defined indicators of achievement, interpreting data relative to established achievement standards, and identifying areas for improving achievement of educational objectives. Assessments require knowledge tests, performance tests, or other student demonstrations of their capabilities. Analysis of the evidence obtained from these assessments leads to conclusions about student achievement in this sampling of their capabilities. The number of performance dimensions used determines the extent to which learning achievement deficiencies can be pinpointed.

8. Provide Feedback

Student performance relative to established standards identifies learning objectives being achieved at substandard levels, places where improvement is required. Information about the substandard performance must be directed to those who revise the curriculum (planned link to objectives) or the learning situations (structure for achieving these objectives) to support improvements. Providing greater detail about performance deficiencies makes revision more

effective. Systematic feedback is essential to support continuous improvement of student learning.

The steps described above are repeated as new information identifies areas where improvement is needed and suggests revisions that may achieve the desired improvement. As discussed above, assessments perform important functions to support improvement of learning. They define educational outcomes (step 1), establish a measurement system for determining achievement of these targets (step 2), and produce data to quantify achievement of a student population and identify where improvements are needed (step 7). These steps will be utilized in later sections to present a mid-program assessment process.

Categories and Levels of Outcomes

Before addressing educational objectives, it is useful to explore design education outcomes in a more general way. The design capabilities of engineering graduates fall within a number of categories and are achieved at different levels. Thus, a structure for discussing educational outcomes includes definitions of categories and levels of design education capabilities.

Practicing engineers must be able to effectively utilize and manage the overall design process, the people engaged in the design activity, and the information resources that support the design process. Thus, three major categories of capabilities to be developed and assessed in engineering education are:

- a. Design Process— Managing, using, and improving elements of the engineering design process,
- b. Teamwork— Managing, utilizing, and developing personnel engaged in the design, and
- c. Communication— Managing, communicating, and extending information associated with the design.

Engineering graduates need proficiency in each of these areas. Different levels of proficiency are appropriate for mid-program outcomes than for end-of-program outcomes. To define distinctions among levels of proficiency, Table 1 presents four TIDEE levels of achievement in engineering design. These four levels, parallel to levels of Bloom’s taxonomy³, define student capabilities increasing from exhibiting basic understanding to being able to critique and improve knowledge and its application. The TIDEE levels of learning are used to establish a matrix framework within which design educational objectives may be defined.

Table 1. Definitions for Levels of Achievement in Design Education Outcomes

<i>Level</i>	<i>Description</i>
BASIC KNOWLEDGE	Recognition and understanding of facts, terms, definitions, descriptions, relationships, processes
APPLICATION OF KNOWLEDGE	Use of knowledge in ways that demonstrate understanding of concepts or terms, their proper use, and limitations of their applicability
CRITICAL ANALYSIS	Examination and evaluation of information required to judge its value to a design solution and to make decisions
EXTENSION OF KNOWLEDGE	Extending knowledge beyond what was received, creating new knowledge, making inferences, transferring knowledge to usefulness in new areas of application, making improvements

Figure 3 presents a matrix of design categories and levels of achievement for design education outcomes. Rows represent the categories and appropriate subcategories. Column labels are the four levels of achievement. Target levels of student capabilities can be presented graphically, as shown by the bars and diamond symbols in this matrix. Mid-program targets obviously are at lower levels than are end-of-program targets. Target levels for subcategories will differ from the target levels for categories because subcategories are not always of equal importance, and therefore all will not be developed to the same extent in a degree program.

Design Educational Outcomes Category-Level Matrix

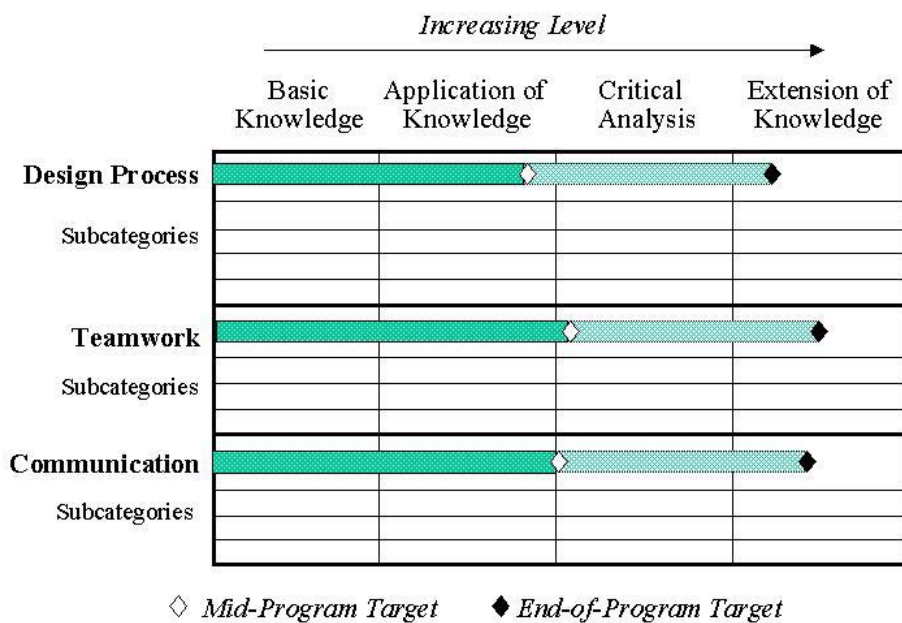


Figure 3. Matrix Structure for Defining Educational Outcome Targets

Through a number of workshops with members of the Washington Council for Engineering and Related Technical Education (WCERTE), the TIDEE project defined entering-junior target levels for different categories of design competencies. WCERTE members indicated that, in a student’s first two years of engineering or technology education, a design foundation should be established to include: teamwork, communication, and the design process. Specific target levels for design process, teamwork, and communication categories ranged from “application of knowledge” to “critical analysis” levels. This suggests that design education objectives for mid-program assessment should include assessments of students’ abilities to explain and apply concepts and, at times, to critique them.

DESIGN EDUCATION GOALS AND OBJECTIVES

Rogers and Santos⁴ suggest that goals and educational objectives be linked to performance criteria before developing assessments for the educational objectives. Goals are broad far-reaching statements defining a desired state. Educational objectives state circumstances by which it will be known that the desired state (level of achievement) has been reached at a given point in time. Performance criteria specify the observable details that evidence the desired state.

Goals

Design education goals define the setting for writing educational objectives relevant to a specific point in a curriculum. Writing design education goals for end-of-program and mid-program conditions helps to delineate differences in expectations, so these two goals are presented below.

End-of-Program Goal

Graduating engineers will be able to develop, perform, and improve team-based design processes that capitalize on team expertise and deliver design products meeting expectations of multiple clients.

Mid-Program Goal

Entering-junior engineering students will be able to perform elementary team-based design.

Objectives

Educational objectives for team-based engineering design stem from the three categories of capabilities defined earlier: design process, teamwork, and communication. One educational objective for each category is written (below) to reflect expectations of the entering-junior engineering student.

Objective 1: Design Process

When given an open-ended design problem, students are able to define and perform steps required to deliver a creative design product that meets clients' expectations.

Objective 2: Teamwork

When students are assigned to groups and given a collective responsibility, they are able to develop appropriate strategies and achieve shared goals, yielding higher quality results than could be achieved individually.

Objective 3: Communication

When students work in design teams, they are able to communicate within and outside the team as required to support team productivity and to achieve the intended impact.

PERFORMANCE INDICATORS

Performance indicators (or criteria) are required to determine if educational objectives have been achieved. For any educational objective, multiple performance criteria are used to span the types of relevant evidence. Performance criteria may be defined as evidence of knowledge, demonstration of process skills, or qualities of products delivered. Performance criteria for the three design education objectives are discussed in the following sections.

Design Process

The engineering design process is an important tool for engineering students to master. The design process provides a structure for addressing creative problem solving or design. As defined in the TIDEE project, there are five elements or subcategories within the engineering design process and (a sixth) the overall management of the process that must be mastered as part of engineering design education. The first five elements are not utilized in a linear fashion, but instead practiced repeatedly and iteratively to utilize new information as available and to continually improve design decisions. Figure 4 illustrates the basic design process.

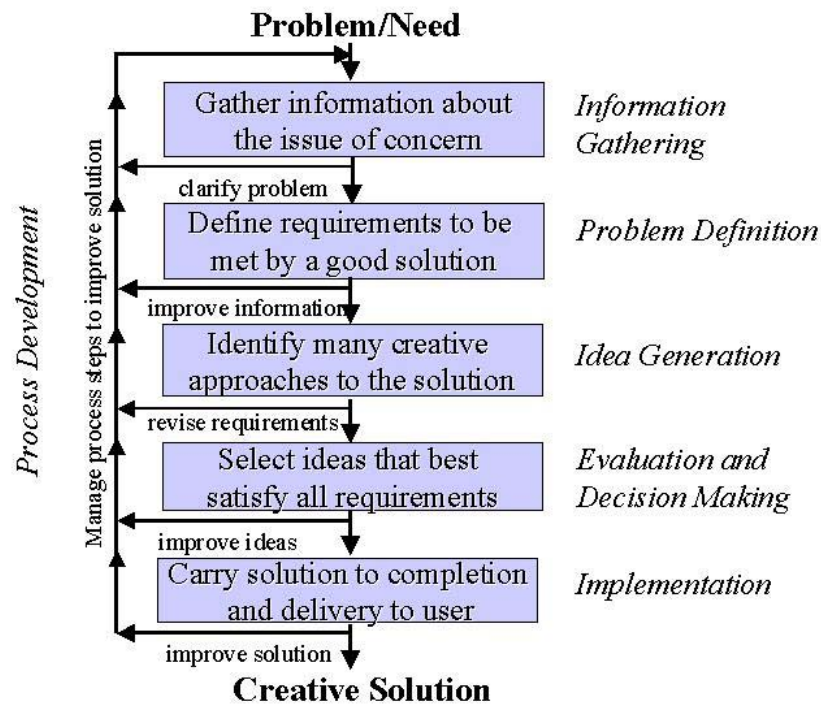


Figure 4. Elements of the Engineering Design Process

The six design process subcategories include:

- Information Gathering— Accessing, acquiring, and evaluating information relevant to design issues.
- Problem Definition— Preparing statements of project goals and specific technical and non-technical design requirements that must be satisfied for a successful design product.
- Idea Generation— Selecting, employing, and improving methods for generating innovative yet relevant ideas as possible approaches to satisfy stated requirements.
- Evaluation and Decision Making— Selecting, utilizing, and judging viability of results from methods for analyzing concepts and making design decisions based on established requirements.
- Implementation— Interpreting and synthesizing information and decisions and taking action to produce useful deliverables for prospective clients.

- Process Development— Managing, evaluating, and improving design activity to use information and resources to achieve design objectives optimally.

Six performance criteria for the **design process** category, derived for entering-juniors from the list of design process subcategories given above, are:

- a. Appropriate information is accessed and used to inform the design process.
- b. Project requirements are defined to include relevant technical and non-technical criteria.
- c. Creative ideas are generated to address needs throughout the design process.
- d. Analysis of ideas and design decisions are based on appropriate methods and criteria.
- e. Design products stem from design decisions and meet client expectations.
- f. Activities in the design process are managed to enhance productivity and product quality.

Teamwork

Management of design personnel as an effective team is essential for any team-based design effort. Team synergy is sought from effective utilization of team member skills and perspectives, establishment of a supportive team working environment, and ensuring that member responsibilities are understood and completed with the team's goals in mind. As is revealed by the well-known team growth stages of forming, norming, storming, and performing⁵, effective teamwork requires time to achieve. This also indicates that stage of growth, and therefore, levels of teamwork achievement can be described and assessed.

Subcategories for teamwork include the following:

- Purpose and Goals— Defining and being motivated by common team purpose and goals.
- Roles and Responsibilities— Understanding and performing responsibilities as required for effective team function.
- Team Attitude— Interacting with other team members in ways that support team cohesiveness, member contribution, and enjoyment.
- Planning— Identifying schedules and monitoring progress toward team goals.
- Resource Management— Utilizing team member skills, information, and other resources effectively.
- Operating Procedures— Understanding and using procedures that support team goals.
- Rewards— Using rewards and recognition to encourage team success.

For entering-juniors, the following performance criteria are derived from subcategories of **teamwork**:

- a. Team purpose and goals are clearly defined and have member commitment.
- b. Members understand their roles and responsibilities and perform them to support team success.
- c. Team members exhibit respect for one another and are motivated by team pride.
- d. Team plans include schedules and milestones that ensure progress toward goals.
- e. Team member empowerment is evidenced by effective use of member skills and other resources.
- f. Members understand and follow procedures that support team success.
- g. Rewards and recognition are used to encourage team success as well as member success.

Communication

Communication of design information takes a number of forms both within a design team and with people outside the team. Timely and accurate information exchange among team members is essential to support prudent design decisions and integration of whole systems. Recording and transmitting information provide the bases for effective marketing, funding decisions, and contracts. Interactions with clients, suppliers, and the general public can determine project success or failure. Clearly, without effective communication, team productivity and effective system design can not exist.

Subcategories of design communication include:

- Structure— Organization of information that makes information understandable in its parts and whole.
- Content— Completeness and accuracy of information that provide confidence about its correctness and usefulness under stated conditions.
- Relevance to Audience— Attributes of communication that make information attractive to an audience.
- Value— Value of information to internal and/or external clients.
- Availability— Convenience and adaptability of information to other uses and to use by other people.

Based on these subcategories, the following performance criteria for entering-juniors are defined for the category of design **communication**:

- a. Information is organized in ways that make it understandable as a whole and as parts of the whole.
- b. Information is complete and its accuracy is stated and documented.
- c. Presentation of information is in the format, vocabulary, level, quality, and appearance that are understood and appreciated by the intended audience.
- d. Information has value for enhancing products of internal and external clients.
- e. Information is available and readily useable to other users.

Performance Criteria for Team-Based Design

Performance criteria for team-based design— derived above from the categories of design process, teamwork, and communication— are summarized in Table 2.

Table 2. Performance Criteria for Entering-Junior Design Education Objectives

Design Education Goal: Entering-junior engineering students will be able to perform elementary team-based design.	
<i>Educational Objectives</i>	<i>Performance Criteria</i>
<u>Objective 1: Design Process</u> When given an open-ended design problem, students are able to define and perform steps required to deliver a creative design product that meets clients' expectations.	<ol style="list-style-type: none"> a. Appropriate information is accessed and used to inform the design process. b. Project requirements are defined to include relevant technical and non-technical criteria. c. Creative ideas are generated to address needs throughout the design process. d. Analysis of ideas and design decisions are based on appropriate methods and criteria. e. Design products stem from design decisions and meet client expectations. f. Activities in the design process are managed to enhance productivity and product quality.

<p><u>Objective 2: Teamwork</u> When students are assigned to groups and given a collective responsibility, they are able to develop appropriate strategies and achieve shared goals, yielding higher quality results than could be achieved individually.</p>	<ul style="list-style-type: none"> a. Team purpose and goals are clearly defined and have member commitment. b. Members understand their roles and responsibilities and perform them to support team success. c. Team members exhibit respect for one another and are motivated by team pride. d. Team plans include schedules and milestones that ensure progress toward goals. e. Team member empowerment is evidenced by effective use of member skills and other resources. f. Members understand and follow procedures that support team success. g. Rewards and recognition are used to encourage team success as well as member success.
<p><u>Objective 3: Communication</u> When students work in design teams, they are able to communicate within and outside the team as required to support team productivity and to achieve the intended impact.</p>	<ul style="list-style-type: none"> a. Information is organized in ways that make it understandable as a whole and as parts of the whole. b. Information is complete and its accuracy is stated and documented. c. Presentation of information is in the format, vocabulary, level, quality, and appearance that are understood and appreciated by the intended audience. d. Information has value for enhancing products of internal and external clients. e. Information is available and readily useable to other users.

ASSESSMENT METHODS

A variety of assessment methods can be used to assess learning during engineering students' first two years. In-class assessments, ranging from short written answers about "What is not working well?" to student problem solving at the chalkboard, can guide improvements to a class. Angelo and Cross⁶ provide over 30 examples of useful classroom assessments of this type. Mid-program assessments can document students' capabilities at the time they transfer between institutions, or they can provide intermediate feedback on achievement toward end-of-program educational objectives. In general, multiple assessments should be used to support improvement of learning.

Assessing achievement of an educational objective requires gathering evidence on the different performance criteria associated with that objective. Clearly, the conditions identified in the statement of the educational objective put constraints on the type of assessment that is suitable. If the objective defines a state of knowledge, then the assessment must allow students to demonstrate that they have this knowledge. If the objective sets an expected level of performance for a process, then the assessment must provide students the opportunity to demonstrate their performance of the process. Because the design process, teamwork, and communication objectives include processes, a performance assessment is needed. The assessment should also investigate students' knowledge underlying these processes so that diagnostic information is available to support making recommendations for knowledge and/or process improvement based on revealed deficiencies.

An entering-junior design assessment, developed in the TIDEE project, is presented as an example of a mid-program assessment⁷. This assessment has three different components to aid in distinguishing between students' achievement in the knowledge and process types of learning. Table 3 identifies differences among the three assessment components. The first component focuses on students' knowledge of the engineering design process, teamwork, and design

communication. The second focuses on students' abilities to use the engineering design process, teamwork, and communication. The third component provides additional information to judge students' understanding of these processes. Typically, the three components are used in the order shown—the pre-test before students engage in a design activity, the group activity during a class period, and the essay as a take-home assignment immediately after the group activity.

Table 3. Components of the TIDEE Entering-Junior Design Assessment

Component Descriptor	Assessment Purpose
1. Short Answer Pre-Test <i>(Knowledge Assessment)</i>	Determine individual students' knowledge of basic concepts about the design process, teamwork, and design communication.
2. In-Class Group Design Activity <i>(Performance Assessment)</i>	Determine the ability of teams to organize and to apply the design process and effective communication to complete a design assignment on time.
3. Post-Activity Reflective Essay <i>(Performance and Knowledge Assessment)</i>	Determine individual students' understanding of design process, teamwork, and communication practices that support effective performance of a team design assignment.

Each component of the Entering-Junior Design Assessment is discussed below.

Knowledge Component

Component 1 of the Entering-Junior Design Assessment is presented in Figure 5. (Appendix A contains a full-page version that may be copied and used.) This component focuses on individual students' knowledge of basic concepts related to the engineering design process, teamwork, and communication.

ENTERING-JUNIOR DESIGN KNOWLEDGE ASSESSMENT
<p>OBJECTIVE: <i>Demonstrate your knowledge of key elements in the engineering design process, teamwork, and communication associated with team-based engineering design.</i></p> <p>ASSIGNMENT: <i>Respond to the following questions/statements. You have 15 minutes.</i></p> <p>A. In a general sense, a process is an ordered set of activities to accomplish a goal. In the space provided, describe and/or diagram your understanding of the engineering design process.</p> <p>B. What kinds of things should teams do to prepare themselves for effective teamwork in a design project assignment? Respond in the form of a list.</p> <p>C. In team-based design, documentation and exchange of design information are important. List characteristics of communication that will be essential in a team design project.</p>

Figure 5. Entering-Junior Design Knowledge Assessment

Performance Component

Component 2 of the Entering-Junior Design Assessment offers a method for assessing students' performance of team-based design as it is utilized in a short design project. Figure 6 presents a condensed version of the design assignment, and the full instrument is found in Appendix A. Students are asked to use teamwork and the engineering design process to complete a design assignment within allotted time. They also are asked to document their processes (their assignment of responsibilities and steps used to complete their assignment) and to record their design products (list of design requirements and a testing procedure). A design journal provides additional opportunity to document team activity and accomplishments.

<p style="text-align: center;">ENTERING-JUNIOR DESIGN PERFORMANCE ASSESSMENT 45 Minute Group Activity</p> <p>Your Assignment: In this exercise you are expected to organize your group into a team which can produce the required deliverables in the 45 minutes allotted. Your final product is a plan for evaluating the extent to which a commercially available tool meets its top three customer requirements.</p> <p>Deliverables:</p> <ul style="list-style-type: none">• Record of member responsibilities• Record of team's design process• Customer requirements• Product testing procedure• Additional notes produced by your team
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Figure 6. Condensed Instructions for an Entering-Junior Design Performance Assessment

Reflection Component

Teams having completed a design exercise can provide information helpful for assessing their performance. Team members know both what they did and what they understood. They can provide more detailed information about their processes and their understanding than is normally available from worksheets and journal notes. Whereas, team self-assessments can provide information about the team as a whole, asking students to write an individual reflective essay reveals information about each student's understanding and written communication skills.

Component 3 of the Entering-Junior Design Assessment is a written essay assignment. The full essay assessment component is found in Appendix A, and a condensed version is presented in Figure 7. Students are instructed to write a reflective essay on what they did and what they understood about using the design process, teamwork, and communication in a team design assignment. The essay can be an in-class or take-home assignment.

ENTERING-JUNIOR DESIGN ESSAY ASSESSMENT

Reflective Essay (45 minutes in class or take-home)

Document your personal understanding of teamwork, the engineering design process, and design communication. Demonstrate your ability to communicate this understanding by preparing a 2-page essay.

A. Design Process

Five elements (sub-processes or activities) used in the engineering design process are:

- Information gathering
- Definition of the problem (design requirements)
- Idea generation
- Evaluation and decision making
- Implementation to produce deliverables

1. Describe specific actions your team employed that fall within these five elements of the design process.
2. Describe how your team managed your design efforts to achieve quality in your design results.

B. Teamwork

1. Identify the responsibilities assigned to each team member, and describe how they were performed.
2. Describe the extent to which members showed support for one another and contributed to the team's overall performance. Give specific examples.

C. Communication

1. Describe the ways design information was managed and communication occurred among team members.
2. Describe any communication qualities that enhanced team understanding and performance.

Figure 7. Condensed Entering-Junior Design Essay Assessment

ASSESSMENT SCORING

Scoring scales and performance standards are required for interpreting assessment data. Scoring scales describe performance at different levels of achievement for a given objective or performance indicator. These scales must span the range of performances anticipated for the population being assessed. Performance standards, on the other hand, identify the achievement level or score targeted for the students participating in the assessment. These may be scores deemed “acceptable” or those “aspired to” by educators or the public.

Defining Scoring Scales

Samples of condensed scoring scales for the Entering-Junior Design Assessment are presented in Table 4. (Appendix B contains the full set of scoring scales for this assessment.) Scores range from a low of 1 to a high of 5, with descriptors provided for scores of 1, 3, and 5. Scores of 5 fit levels beyond the expected achievement for entering-junior engineers, allowing exceptional performance to be recognized with this scale. The 5 score also is useful for communicating to students and faculty what is meant by exceptional performance, thereby guiding their efforts to improve.

Table 4. Sample Abbreviated Scoring Scales for Entering-Junior Design Assessment

CATEGORY: DESIGN PROCESS	
Subcategory: Problem Definition	
1	5
No design requirements stated, or few but ambiguous at best.	Goal and requirements defined fully, revised over time, address technical and non-technical issues such as performance, cost, reliability, manufacturability, and safety.
Subcategory: Evaluation and Decision Making	
1	5
Only cursory analysis of ideas; decisions made arbitrarily.	Quantitative and qualitative issues analyzed; appropriate analytical and experimental methods, tools, and information used; decisions based on established criteria.
Subcategory: Process Development	
1	5
Design steps performed linearly without steps toward improvement	Process elements repeated, used iteratively to improve results; design process planned, recorded, and reviewed for improvement.
CATEGORY: TEAMWORK	
Subcategory: Purpose and Goals	
1	5
Team goals nonexistent or poorly defined; members clueless about team goals.	Team driven by clear goals; members know goals and how will be assessed; members committed to common purpose.
Subcategory: Roles & Responsibilities	
1	5
Team members have no clear role assignments or role ownership; important roles not performed.	Members understand responsibilities; team defines, enforces expectations; members own and fulfill their roles to support team; all important roles covered well.
Subcategory: Resource Management	
1	5
Team without adequate skills and resources to complete project; no effort to obtain needed resources.	Team has proper mix, levels of skills needed for project; team uses talents, knowledge, skills of all members; other resources accessed and used effectively.
CATEGORY: COMMUNICATION	
Subcategory: Content	
1	5
Information incomplete or has obvious errors; overall reliability questioned.	Information stated clearly, completely, and accurately; measures of reliability stated and justified.
Subcategory: Relevance to Audience	
1	5
Information not relevant to audience as presented.	Information in form, appearance, language, and level attractive and understandable to intended audience; understanding communicated well.
Subcategory: Value	
1	5
Information recorded or communicated has little value to design team or others.	Information is timely and of great value to team and to others; supports quality design decisions and value-added actions by others.

Assigning scores to students' achievements on the Entering-Junior Design Assessment is accomplished by applying the scoring scales to the evidence obtained from the different assessment components. A separate score can be assigned for each student, for each assessment

component, and for each subcategory defined under the design education objectives. Alternatively, each student can be assigned one score for each of the three design education objectives or one score for the overall team-based design goal. Finally, one score can be assigned to an entire team or collectively to all participants in the assessment.

The decision about the number of scores to use depends upon the purposes of the assessment and considerations of resources required to complete the scoring. As indicated by Trevisan et al⁸, holistic scoring (one overall score for each person) gives little information to guide revisions and improvement. On the other hand, analytic scoring (scoring each performance dimension or category or subcategory) provides diagnostic information about students' weaknesses, indicating details about improvements needed. Analytic scoring also requires much more effort than does holistic scoring. For a mid-program assessment, detailed assessment knowledge is desirable, so an analytic scoring approach is addressed here.

Assigning Scores

Assessment scores are assigned by comparing evidence of students' capabilities to relevant performance criteria. Table 5 maps the Entering-Junior Design Assessment information (evidence available through the three assessment components) to the performance criteria for each of the educational objectives. The ease of scoring for a performance criterion depends upon the amount of evidence related to that criterion and the correspondence between the evidence and the scale for that criterion. As can be seen from Table 5, the essay provides the best overall evidence (but it depends upon students having completed the group activity first). Some of the performance criteria (e.g., value) will be difficult to evaluate through this assessment, and others (e.g., problem definition) provide ample evidence to evaluate.

Table 5. Mapping Assessment Evidence to Performance Criteria

Performance Criteria	Component 1: Pre-Test	Component 2: Group Activity	Component 3: Essay
DESIGN PROCESS			
Information Gathering	M(A)*	M(W1)	G(A.1)
Problem Definition	M(A)	M(W1)	G(A.1)
Idea Generation	M(A)	M(W1)	G(A.1)
Evaluation & Decision Making	M(A)	M(W1)	G(A.1)
Implementation	M(A)	M(W1)	M(A.1)
Process Development	M(A)	P(W1)	G(A.2)
TEAMWORK			
Purpose & Goals	M(B)	P(J)	P(B.2)
Roles & Responsibilities	M(B)	M(W1)	G(B.1)
Team Attitude	P(B)		G(B.2)
Planning	M(B)	M(J)	M(B.1)
Resource Management	P(B)	P(J)	P(B.1)
Operating Procedures	P(B)		P(B.2)
Rewards	P(B)		P(B.2)
COMMUNICATION			
Structure	M(C)	P(W2)	M(C.2)
Content	G(C)	M(J), M(W2)	G(C.2)
Relevance to Audience	M(C)		G(C.2)
Value	P(C)		
Availability	M(C)		M(C.1)

*Notes: G = good evidence, M = moderate evidence, P = poor evidence

Parentetical letters refer to question number or journal (J) or worksheets (W1 or W2)

Scoring examples are useful to illustrate how assessment evidence is scored. An example is given below for scoring design process knowledge and a second example for scoring teamwork knowledge.

Scoring Example 1—Design Process

Figure 8 shows a sample student response to question A of the Entering-Junior Design Knowledge Assessment. This student responded using only words and no diagram, so the entire response is quoted.

<p>Question: In a general sense, a process is an ordered set of activities to accomplish a goal. In the space provided, describe and/or diagram the engineering design process, as you understand it.</p> <p>Student Response: <i>“The process begins with an objective. Brainstorming begets the best means of achieving the objective. The selected method is worked out in detail, then engineered. The engineered product is fine-tuned based upon its performance and the performance criteria.”</i></p>
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Figure 8. Student Response to Design Process Question

Table 6 shows rationale for scoring this student’s response. Six different scores are assigned for the different performance criteria for the design process category. An overall score of 3 is assigned for this student’s knowledge of the design process.

Table 6. Design Process Scores for Sample Student Response to Pre-Test Question A

Subcategory	Score	Rationale
Information Gathering	1	Not evident at start; implied by plan to look at performance
Problem Definition	2	A goal is defined as a starting point; criteria not mentioned
Idea Generation	3	Brainstorming is used to address the objective
Evaluation & Decision Making	3	Performance criteria used to judge refinements
Implementation	3	Selected design is worked out in detail
Process Development	3	Most elements present; refinement after details are defined shows iteration
Overall Design Process	3	Predominant score is 3; basic process is understood

Scoring Example 2—Teamwork

Figure 9 shows a different student’s response to the teamwork question (question B) of the Entering-Junior Design Knowledge Assessment. This student responded with a list of five actions to be taken or issues to be addressed by a team.

Question:

What kinds of things should teams do to prepare for effective performance in a design project assignment? Respond in the form of a list.

Student Response:

- *Assign job titles (leader, recorder, reflector)*
- *Make sure everyone agrees on nature of problem for project*
- *Cooperate and encourage any and all ideas as possible solutions*
- *Utilize all available references and tools*
- *Take responsibility for work; be willing and able to support design*

Figure 9. Student Response to Teamwork Question

Scores for this student’s performance on the teamwork question are presented in Table 7. A number of the teamwork performance criteria are met at a high level, indicating teamwork knowledge beyond a rudimentary level. For an entering-junior, this response is evidence of a very good understanding of teamwork basics. A score of 5 is assigned for teamwork knowledge based on the pre-test evidence.

Table 7. Teamwork Scores for Sample Student Response to Pre-Test Question B

Subcategory	Score	Rationale
Purpose and Goals	4	Agreeing on nature of problem clarifies goals and results in buy-in to goals
Roles and Responsibilities	4	Assigning jobs includes key roles; take responsibility for work implies commitment to responsibilities
Team Attitude	4	Cooperation and encouragement of ideas among team members indicate positive attitude
Planning	1	Assigning leader implies some need to plan? No mention of scheduling team activities
Resource Management	4	Using all available references and tools; using people implied by encouraging participation
Operating Procedures	4	Using roles, gaining agreement, encouraging ideas, willingness to support design define practices
Rewards	1	Encouragement as an incentive?
Overall Teamwork	5	Important criteria for effective teams satisfied; clearly understands basics of teamwork; some criteria met at high level

The assignment of overall scores is not simply a mean of scores for individual criteria. Instead, it reflects the extent to which the student grasps the breadth of issues relevant to the performance category and demonstrates some depth in important subcategories of performance. Thus, in both examples given the overall score is higher than the average of individual criteria scores.

ASSESSMENT FEEDBACK

Assessment feedback should include both a performance score and a judgment of this performance relative to established standards for the population of students participating in the assessment. As was noted above, the Entering-Junior Design Assessment provided only marginal evidence for some of the performance criteria. Two scenarios exist for addressing this issue. First, if the assessment properly reflects performance expectations, the performance

criteria lacking evidence are relatively unimportant at this point and can be ignored. Second, if all performance criteria are important, the assessment needs revision to provide better evidence for the neglected criteria. In either case, as part of the feedback on student performance, statements should be made to clarify the adequacy of the evidence used to determine performance levels and the implications of this information on interpreting assessment results.

Design Performance Standards

In this document, design performance standards or achievement targets are defined for engineering students at the midpoint of their baccalaureate degree programs. Standards are established here for each of the three design education objectives (i.e., categories of: design process, teamwork, and communication), although a standard for each subcategory could be defined as well.

An achievement standard is established by considering the levels of performance sought relative to the multiple performance criteria for that objective. Standards may require minimal achievement in some or all of the performance criteria. A standard may also require a specific level of achievement in designated performance criteria. Tables 8, 9, and 10 present mid-program performance standards in the engineering design process, teamwork, and design communication.

Table 8 shows standards of performance expected at mid-program in the area of the engineering design process. Students at this point in their programs are required to understand the primary elements of the process and its relationship to creating design products meeting design requirements. They also are expected to realize that design has an iterative character. At this stage, students will not have mastered the design process at a high level, but they will have some depth of knowledge in aspects of the design process.

Table 8. Mid-Program Achievement Standard for Design Process Performance

Design Process Achievement Standard	Target Score
<ul style="list-style-type: none"> • Able to identify four of the design process elements (information gathering, problem definition, idea generation, evaluation and decision making, implementation, and process development) and demonstrate their use in a design exercise. • Show some depth of understanding in at least two of these elements. • Realize that a design product must satisfy a set of design requirements. • Aware of the need to improve a design beyond a first pass. 	3

Table 9 shows the mid-program performance standards for students in the area of teamwork. An essential requirement is their realization of a need for structured role assignments, especially for team leadership and recording of information. Students also need to realize that they must create an environment that supports team cooperation and participation. Of lesser importance is understanding the broader set of effective team qualities and their ability to practice these. At this point, students are able to form a team and to exhibit rudimentary team skills.

Table 9. Mid-Program Achievement Standard for Teamwork Performance

Teamwork Achievement Standard	Target Score
<ul style="list-style-type: none"> • Recognize the need for roles to support teamwork, identifying team leader and recorder as a minimum. • See need for supportive relationships among members and demonstrate some action to support one another. • Understand need for at least half of the following: team goals, member roles, positive environment, time management, utilization of member strengths, defined procedures, and rewards. 	3

Table 10 presents mid-program achievement standards in the area of design communication. Of essence are students’ abilities to present information comprehensibly, making information understandable to the intended audience. The attractiveness of information may be less than desired. There also may be doubt about the preciseness of information. Audience impact and value to the audience likely will need improvement. Students also need to be aware of some basic quality attributes of design information, although they may not be adept at delivering these yet. A degree of professionalism in design information is not evident at this point in students’ growth.

Table 10. Mid-Program Achievement Standard for Design Communication

Communication Achievement Standard	Target Score
<ul style="list-style-type: none"> • Information presented in understandable format and language, but some details missing or unclear. • Communication appropriate for intended audience, but impact and value to audience are less than desired. • Aware of at least half of the following quality attributes for design information: organization, accuracy, audience focus, value to audience, availability to others. 	3

Target scores for the three dimensions of design education achievement are obtained by comparing the achievement standards to the scoring scales for those performance criteria. As noted in the previous tables, a score of 3 was assigned to each dimension. This indicates that expected achievements in the three dimensions are similar and are midway on the scales defined for this assessment. This allows the assessment to identify both high and low achievement in each performance dimension.

Providing Feedback

Assessment feedback desired from the mid-program assessment includes an achievement score, to indicate the students’ achievement level, and some analysis of students’ performance. At the mid-program point, separating students’ scores according to the institution from which they transferred will be useful to inform institutions about the overall design preparation of their students. Identifying separate scores for design process, teamwork, and communication helps identify relative performance in these three areas. Examination of scores for individual performance criteria may be practical only in problem cases, when more information is required to reveal knowledge commonly missing so corrective action can be taken.

Table 11. Format for Providing Assessment Feedback

<i>Description</i>	<i>Design Process</i>	<i>Teamwork</i>	<i>Communication</i>
Overall Performance			
Your Performance			
<p>Scores are based on scales from 1 (low) to 5 (high). For students midway through their engineering baccalaureate degree programs, targeted scores are 3.</p> <p>Each score is based on evidence from three assessment exercises: a short answer pre-test, a 45-minute group design activity, and a 2-page essay (take-home) based on the group design exercise.</p> <p>Design process performance criteria are: information gathering, problem definition, idea generation, evaluation and decision making, implementation, and process development.</p> <p>Teamwork performance criteria are: purpose and goals, roles and responsibilities, team attitude, planning, resource management, operating procedures, and rewards.</p> <p>Communication performance criteria are: structure, content, relevance to audience, value, and availability.</p>			

This assessment feedback should be used to revise curriculum, courses, or learning exercises, and thereby improve students' development of team-based design capabilities. Systematic mid-program assessment, providing focused feedback, and making revisions can improve preparation of students for advanced level design education. Effective design education is central to preparing graduates for professional practice and for gaining accreditation of engineering degree programs.

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APPENDIX A: MID-PROGRAM DESIGN ASSESSMENT INSTRUMENT

Appendix A contains assessment materials for use in mid-program assessment— actual full-page instruments for photocopying and use in assessment. The TIDEE Entering-Junior Design Assessment is presented here, with separate components for knowledge, performance, and reflection. A student information sheet is provided to obtain background information from students for use in tracing performance to student educational backgrounds. Two worksheets are included for the performance component. Scoring criteria for these assessments are found in Appendix B.

Knowledge Component

The knowledge component of the Entering-Junior Design Assessment is used to determine students' general understanding of the engineering design process, teamwork, and communication used in design. Three open-ended assessment questions allow students to demonstrate their knowledge in their own language and style. This approach minimizes concerns about the assessment having terminology different than that used by faculty at different institutions from which students come. Students' open-ended responses also provide information about their vocabulary and their abilities to communicate verbally and/or graphically.

This component of the assessment is useful as a pre-test. It is easy to administer in class and takes very little class time. Scoring is simplified by having a separate question for each category (design process, teamwork, communication) being scored. When used as a pre-test, for example on the first day of a junior class, students suddenly realize that design is an important part of what they are expected to know and design will be important to this class.

The knowledge component of the Entering-Junior Design Assessment provides a measure of students' design capabilities at the "basic knowledge" level— concepts, but not design skills. Separate scores for design process, teamwork, and communication provide indicators of students' knowledge in each of these three areas of design. This information is useful as a diagnostic for low performance in the design performance assessment (component 2).

ENTERING-JUNIOR DESIGN KNOWLEDGE ASSESSMENT

Name: _____

Date: _____

Objective: *Demonstrate your knowledge of key elements in the engineering design process, teamwork, and communication associated with team-based engineering design.*

Assignment: *Respond to the following questions/statements. You have 15 minutes.*

A. In a general sense, a process is an ordered set of activities to accomplish a goal. In the space provided, describe and/or diagram your understanding of the **engineering design process**.

B. What kinds of things should teams do to prepare themselves for effective **teamwork** in a design project assignment? Respond in the form of a list.

C. In team-based design, documentation and exchange of design information are important. List characteristics of **communication** that will be essential to support a team design project.

Performance Component

Component 2 of the Entering-Junior Design assessment is a performance assessment. Students are asked to work as teams to accomplish a design assignment in a short time period. This component of the assessment allows students to demonstrate their design skills— an “application of knowledge” level for design education outcomes.

Assessment component 2 can be administered during a 50-minute class period. Group students into teams of three to five persons for this exercise. Team composition may be randomly assigned or based on specific criteria of interest (e.g., school or program from which students received their previous design education). Each team is given copies of the design assignment and two worksheets to be completed during the allotted time. Introduction to the assessment can be as brief as stating why the assessment is being done, how results will be used, and reading the assignment instructions. This allows the teams a full 45 minutes to complete their assignments.

Quality of the assessment results depends upon the attitudes of the students and the care with which they complete worksheets. Scoring requires worksheets to be completed well, providing a true representation of what was done. Separate scores can be assigned for design process, teamwork, and communication— based on criteria and scoring scales presented earlier.

ENTERING-JUNIOR DESIGN PERFORMANCE ASSESSMENT

45 Minute Group Activity

Objective:

Demonstrate your ability to work as a team, to employ the engineering design process, and use effective design communication to accomplish a design assignment.

Your Assignment:

In this exercise you are expected to organize your group into a team which can produce the required deliverables in the 45 minutes allotted. Your final product is a plan for evaluating the extent to which a commercially available tool meets its top three customer requirements.

Deliverables:

- Record of your team members' responsibilities
- Record of the design process your team used
- Your list of customer requirements for the tool
- Your team's definition of a product testing procedure
- Additional notes produced by your team

Resources Available:

- Tool specimen and associated product information
- Worksheet 1: "Responsibilities and Team Design Process Log"
- Worksheet 2: "Customer Requirements and Product Testing Procedure"
- Extra paper
- 45 minutes of team work time

Worksheet 1: Responsibilities and Team Design Process Log

Team: _____

A. Define each team member's roles/responsibilities for this activity:

Name	Role	Responsibilities
•		
•		
•		
•		
•		

B. Record the steps your team uses to complete this activity:

- Step (name or briefly describe)
-
- 1.
 - 2.
 - 3.
 - 4.
 - 5.
 - 6.
 - 7.
 - 8.

C. What were the primary strengths of your team in this design activity?

Worksheet 2: Customer Requirements and Product Testing Procedure

Team: _____

Product to Test: _____

A. Top 3 Customer Requirements (list with brief explanation):

- 1.
- 2.
- 3.

B. Testing Procedure for Each Requirement:

List steps. As appropriate, include sketches or specifics about data collection and use.

Reflection Component

The essay component of the Entering-Junior Design Assessment asks students to reflect on their team performance and to integrate this with their knowledge of design concepts. Thus, this component provides an opportunity to show the depth of students' understanding— perhaps reaching levels of “critical analysis” or “extension of knowledge.” Because the highest levels of knowledge are not expected from entering juniors, questions request information that is more closely “application of knowledge” and slightly into “critical analysis.”

The essay (assessment component 3) asks students to write responses to questions or statements in three areas: design process, teamwork, and design communication. Students are to describe what they did and how they did these things. Their responses are intended both to illuminate what the team did (performance information) and what they understood about the processes that occurred (knowledge). Requesting a 2-page essay guides them to organize and communicate information intelligibly, thus providing an indication of individual students' abilities in written communication.

Scoring of the essay component is done using the same scoring criteria as for the other components of the essay. Because the instructions for writing the essay are given in three parts, the essay normally provides assessment evidence grouped by design process, teamwork, and communication— thus, simplifying scoring. Separate scores are given for each of these design performance categories.

ENTERING-JUNIOR DESIGN ESSAY ASSESSMENT

Reflective Essay (45 minutes, in-class or take-home)

Document your personal understanding of teamwork, the engineering design process, and design communication. Demonstrate your ability to communicate this understanding effectively in written form. Prepare a 2-page essay (double-spaced in a 12 point font) in which you address the items listed below.

A. Design Process

Five elements (sub-processes or activities) used in the engineering design process are:

- Information gathering
 - Definition of the problem (design requirements)
 - Idea generation
 - Evaluation and decision making
 - Implementation of decisions to produce deliverables
1. Describe specific actions your team employed that fall within these five elements of the design process.
 2. Describe how your team managed all of your design efforts to achieve quality in your design results. Give specific examples.

B. Teamwork

In the group activity, your team was asked to assign roles and responsibilities appropriate for completing the assignment.

1. Identify the responsibilities assigned to each team member, and describe how they were performed.
2. Describe the extent to which members showed support for one another and contributed to the team's overall performance. Give specific examples.

C. Communication

As your team performed its assignment, it needed to manage information and communicate.

1. Describe the ways information was managed and communication occurred among team members.
2. Describe any communication qualities that enhanced team understanding and performance.

APPENDIX B: MID-PROGRAM DESIGN ASSESSMENT SCORING SCALES

Appendix B contains complete sets of scoring scales for use in scoring student performance on a Mid-Program Design Assessment. Separate scales are provided for categories of design process, teamwork, and design communication. Within each category, scales are provided for a number of subcategories of that dimension of students' design performance. Appendix C provides examples of scoring for sample student responses to the Entering-Junior Design Assessment.

Scoring Scale for Mid-Program Team-Based Design

CATEGORY: DESIGN PROCESS				
Subcategory: Information Gathering				
1	2	3	4	5
No information gathered specifically to support design.		Information gathered primarily once or from single source; aware that information varies in quality.		Varied sources used to obtain information; some judgment of information quality; information gathered multiple times.
Subcategory: Problem Definition				
1	2	3	4	5
No design requirements stated, or few but ambiguous at best.		General design goal stated; design requirements of both technical and non-technical nature defined.		Goal and requirements defined fully, revised over time, address technical and non-technical issues such as performance, cost, reliability, manufacturability, and safety.
Subcategory: Idea Generation				
1	2	3	4	5
Need for creativity not addressed or inept at being creative.		Idea generation used to add creativity to design products; used once; only one method used.		Creative ideas sought to improve design products; used more than once; multiple methods used; creative environment sustained.
Subcategory: Evaluation and Decision Making				
1	2	3	4	5
Only cursory analysis of ideas; decisions made arbitrarily.		Analysis limited in perspectives considered; numerical analysis of uncertain reliability.		Quantitative and qualitative issues analyzed; appropriate analytical and experimental methods, tools, and information used; decisions based on established criteria.
Subcategory: Implementation				
1	2	3	4	5
No deliverables produced or they fail to meet requirements.		Design decisions converted to deliverables; design products meet primary requirements.		Decisions integrated to yield design products that satisfy system requirements; products delivered on time and within allowed resources.
Subcategory: Process Development				
1	2	3	4	5
Several design elements not used; no effort to improve.		All design process elements evident; some iteration to improve the desired product.		Process elements used, repeated to improve results; design process planned, recorded, and reviewed for improvement.
OVERALL CATEGORY: DESIGN PROCESS				
1	2	3	4	5
Most design elements not evidenced; no effort to manage process.		Most design elements evidenced; few show depth of understanding; need for iteration recognized.		All design elements evidenced, some repeated to improve results; depth of understanding seen for several elements; good process management.

Scoring Scale for Mid-Program Team-Based Design

CATEGORY: TEAMWORK				
Subcategory: Purpose and Goals				
1	2	3	4	5
Team goals nonexistent or poorly defined; members clueless about team goals.		Team has stated goals; members marginally knowledgeable, moderately committed to goals.		Team driven by clear goals; members know goals and how will be assessed; members committed to common purpose.
Subcategory: Roles & Responsibilities				
1	2	3	4	5
Team members have no clear role assignments or role ownership; important roles not performed.		Most members have roles, at least manager and recorder identified; moderately effective in roles.		Members understand responsibilities; team defines, enforces expectations; members own and fulfill their roles to support team; all important roles covered well.
Subcategory: Team Attitude				
1	2	3	4	5
Team members are disrespectful and critical in spirit		Team members share a polite acceptance of one another but exhibit no team cohesiveness or team pride.		Members foster respect, encourage contributions from one another; members show pride in the team, are confident and motivated toward team success.
Subcategory: Planning				
1	2	3	4	5
Team does not have a plan to guide efforts toward timely completion of goals.		Team has plan to complete team goals on time; major milestones identified in plan.		Team has a schedule to accomplish individual and team goals; milestones identified and monitored to ensure all members complete work on time.
Subcategory: Resource Management				
1	2	3	4	5
Team without adequate skills or resources to complete project; no effort to obtain needed resources.		Team has primary skills needed; member capabilities used ineffectively; other resources not accessed or used well.		Team has proper mix, levels of skills needed for project; team uses talents, knowledge, skills of all members; other resources accessed and used effectively.
Subcategory: Operating Procedures				
1	2	3	4	5
Team does not have defined procedures for working together.		Operating procedures in team defined and understood; members generally support them.		Operating procedures defined, understood, supported by members; support effective interaction, decision making, and productivity.
Subcategory: Rewards				
1	2	3	4	5
Disincentives for team success; other recognition for achievement rare.		Occasional reward or recognition; team success not given adequate recognition.		Team success clearly recognized and rewarded; members acknowledge individual and team achievements.
OVERALL CATEGORY: TEAMWORK				
1	2	3	4	5
Most of teamwork subcategories missing; no roles assigned.		Team exhibits half of the subcategories; roles assigned; some effort to encourage cooperation.		Team clearly organizes, makes assignments, allocates time and resources, sets procedures and climate that support team success; members buy-in and strive for team success.

Scoring Scale for Mid-Program Team-Based Design

CATEGORY: COMMUNICATION				
Subcategory: Structure				
1 Information in random or illogical order; meaning confused by disorder.	2	3 Organization makes information understandable; some improvement needed.	4	5 Information organized to delineate details and relationships, flow of thoughts, major themes, and key points; highly understandable.
Subcategory: Content				
1 Information incomplete or has obvious errors; overall reliability questioned.	2	3 Contains essential information; content appears accurate, but validity not documented.	4	5 Information stated clearly, completely, and accurately; measures of reliability stated and justified.
Subcategory: Relevance to Audience				
1 Information not relevant to audience as presented.	2	3 Information in form understandable to audience, details of appearance or language not effective.	4	5 Information in form, appearance, language, and level attractive and understandable to intended audience; understanding communicated well.
Subcategory: Value				
1 Information recorded or communicated has little value to design team or others.	2	3 Information is useful to others for making design decisions; communication adds value to products.	4	5 Information is timely and of great value to team and to others; supports quality design decisions and value-added actions by others.
Subcategory: Availability				
1 Information not shared with others who could benefit.	2	3 Information made available to others on semi-regular basis; timeliness and relevance limit value.	4	5 Information made available to others continuously and conveniently; processes for transfer clearly defined and effective to support team and others needing access.
OVERALL CATEGORY: COMMUNICATION				
1 Information basically not reliable, understandable, or useful.	2	3 Information is of value but not as complete and useful as desired; half of subcategories show weaknesses.	4	5 Information of high quality and usefulness; exhibits positive attributes in all subcategories, some score very high.