Transferable Assessments for Capstone Engineering Design

RESULTS FROM PRIOR NSF SUPPORT

Project: Regional Implementation of Transferable Integrated Design Engineering Education. EEC 9973034 and 0003291. Award: $800,000. Period: (10/99 – 08/04). PI: Denny C. Davis.

The Transferable Integrated Design Engineering Education (TIDEE) consortium has brought together 2- and 4-year educational institutions to develop and adopt effective educational materials for engineering design education. First, TIDEE developed consensus definitions for design education outcomes in Washington State. Next, TIDEE created collaborative learning activities for student learning of design-related processes[1]. TIDEE (led by Washington State University, Seattle University, University of Washington, University of Idaho, Tacoma Community College, and Green River Community College) engaged Pacific Northwest institutions in further development, testing, and use of instructional materials and assessments – primarily for the first two years of engineering design curriculum[2-10]. Many of these materials are available through the TIDEE web site[11]. The Washington Council for Engineering and Related Technical Education (WCERTE), Pacific Northwest Section of the American Society for Engineering Education (ASEE), Pacific Northwest Roundtable for Engineering Education, and others provided valuable input to these efforts. TIDEE has refined, tested, and disseminated a 3-part Design Team Readiness Assessment (DTRA) shown to have high inter-rater reliability and face validity for measuring team-based design skills[3,6,9,12]. TIDEE also developed a web-based alumni survey aligned with outcomes of Engineering Criterion 3 of the Accreditation Board for Engineering and Technology (ABET)[13,14].

TIDEE has also investigated practices in capstone engineering design course instruction and assessment. A national survey of capstone design faculty elicited over 300 responses across engineering disciplines[15]. McKenzie found that 57% of capstone design projects are yearlong, a significant increase over 31% reported in 1995 [16]. Respondents generally felt that none of the ABET Criteria 3 and 4 competencies are currently assessed to the extent possible. Many conveyed discomfort about their classroom assessment practices in capstone design. Over 150 engineering professors from more than 100 programs showed interest in collaborating to develop high-quality assessment instruments for capstone design projects. Most recently, Davis et al., with 100 capstone design instructors and industry engineers, defined a profile of a top quality engineer at graduation and five years thereafter[17]. These developments show the need and the TIDEE resource base for establishing assessments for capstone engineering design courses.

Resources created by TIDEE projects and available for use in the proposed project include:

- Collaborative learning activities for teaching engineering design process, teamwork, communication, and professional skills related to capstone engineering design,
- Design Team Readiness Assessment instruments, pilot tested and implemented at several institutions, with face validity and inter-rater reliability of 85% for a mean of three raters,
- A collection of outcome definitions and assessments used by capstone design instructors across the nation,
- A profile of a top quality engineer, defined by 100 academic and industry engineers, and
- A web site with a variety of design education resources: www.tidee.cea.wsu.edu.

BACKGROUND

More than a decade ago, Richard Stiggins made a strong case for classroom assessment as the cornerstone to effective instruction[18]. He argued that with clear targets and appropriate assessment strategies, students will be more likely to succeed and increase their achievement since they will understand what is expected of them. In addition, Black and Wiliam conducted an extensive literature review and synthesis of classroom assessment practices across grades, disciplines, and countries[19]. This review documented overwhelming evidence for the positive role classroom assessment can play for enhancing student achievement and academic well being.

Capstone design courses are culminating experiences for undergraduate engineering students. High quality classroom assessment is therefore vital to capstone engineering design courses because of the pivotal roles they play in engineering curricula. They are a required part of any accredited baccalaureate engineering degree program in the US, as specified by Engineering Criterion 4 of the Accreditation Board for Engineering and Technology (ABET)[14]. Their frequent use of industry-sponsored projects affords them unique roles for developing and assessing students' skills in a client-driven environment[20,21]. The complex, open-ended projects test students' abilities to draw on previous knowledge, integrate that knowledge, employ creativity, exhibit professional attributes, perform on teams, and develop solutions constrained by economic, social, and technological issues. Capstone design courses provide a rich environment for assessing a variety of student learning outcomes and associated program achievements.

Capstone design courses share several attributes with adult education programs. Principles of adult learning include team-based activities, work on real-life projects, and reflection[22-24]. The development of assessments for capstone engineering design courses, therefore, offers potential models for many other fields of study important to higher education today.

Faculty definitions of capstone engineering design outcomes and related assessment practices vary greatly[15]. Many instructors assess student work in capstone design courses by focusing on design steps more than on the quality of design products[25]. Others focus on design products with little attention given to design processes[15]. However, for engineering students to be successful after graduation, they must produce high quality products while also refining their processes and developing professionally to support continuous improvement of product quality. Outcomes addressed by the TIDEE consortium place greater emphasis on design knowledge and process skill development early in a curriculum and later shift learning toward product quality and professional performance outcomes[26]. This suggests that assessments for capstone design courses address outcomes of process, product, and professional attribute (social and affective) types.

Learning outcomes relevant to capstone design courses have been reported for entire engineering programs and for design alone. Faculty defining educational outcomes for program accreditation often closely follow ABET Engineering Criterion 3 outcomes[14,15]. Published reports on industry needs provide additional definitions, but they often are not written as measurable outcomes[27-30]. Hanneman defines outcomes as attributes and key actions desired from experiential learning (such as internships and co-ops), determined from statistical sampling of stakeholders[31]. Learning outcomes for engineering are also defined within the ABET Engineering Criterion 3 framework at each level of Bloom's taxonomy[32-33]. Kline et al. reported performance measures specifically for engineering design at five levels across ten performance factors[34]. Engineering design outcomes established for assessment across programs at one institution provide separate definitions for: design, communication, teamwork, etc. outcomes[35]. Ten capstone design course outcomes are suggested by Davis et al.[17]. Ideally, outcomes defined for capstone engineering design courses should encompass those mentioned, but they should also reflect high-level integrated performances that are unique to capstone design courses.

Learning outcomes for capstone engineering design courses should reflect cognitive learning theory as applicable in the curricular context of the capstone course. From a cognitive perspective, learning of design includes development of declarative knowledge, procedural knowledge, and metacognitive processing[36]. Higher development of design skills is evidenced by higher quality designs, gathering more information that spans more categories, more transitions among design steps, greater progress in the design process, more effective iteration, and greater understanding of characteristics of design activity[37,38]. Higher levels of learning also evidence greater self-motivation and confidence, integration of knowledge, self-growth, and transformational impact on others[39].

A small set of assessments have been reported for measuring achievement of engineering design outcomes. These include a variety of outcome types and methods for obtaining data. The TIDEE Design Team Readiness Assessment (DTRA) focuses on assessing intermediate-level design outcomes and uses a design knowledge test, a simulated team design performance, and a reflective essay to assess learning of the design process, teamwork, and design communication[40]. Researchers have used the DTRA in a variety of settings: As a pre-assessment for capstone design[10], for facilitating learning in freshman and sophomore engineering classes[8], or, after slight modification, as a pre- and post-assessment for capstone design[41]. Atman and colleagues have used verbal protocol analysis to distinguish and understand levels of design performance for student teams, techniques too labor intensive for routine assessment of design performances[42-44].

Few assessments are reported for capstone engineering design courses. Sobek and Brackin, for example, have separately analyzed design portfolios to assess performance in actual capstone design projects[25,35]. Most capstone course instructors use their own scoring rubrics for assessing project reports, without independent monitoring of assessment quality[15,25]. In short, few transferable assessment tools exist for capstone engineering design instructors. Faculty are left to develop their own assessments, a practice in which most faculty have little confidence[15].

NEED

The need for established capstone engineering design project assessments is critical and widespread. As noted previously, capstone design courses are vital to engineering programs and their accreditation. They are imperative to ensure that desired learning is achieved. Once developed, proven capstone design assessments can raise standards for student learning, communicate to students what achievement in design capstone courses looks like, provide the mechanism for faculty to support students in professional development, and enable benchmarking that supports program improvement. Their absence leaves capstone courses as targets for criticism, students vulnerable to course unpredictability, and improvement ineffective from poor feedback.

Capstone design course assessments need to be applicable across disciplines and institutions. Although capstone engineering courses vary, they do enjoy a set of common characteristics.

Foremost, all contribute to satisfying ABET Engineering Criteria for program accreditation. A capstone design course that addresses Criterion 3a-k outcomes aids in program accreditation and assessment. ABET Engineering Criterion 4 can be satisfied by a capstone design course that (a) is based on knowledge and skills acquired in earlier coursework, and (b) incorporates engineering standards and realistic constraints that include most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political[14]. Thus, ABET criteria frequently shape capstone engineering design courses.

Capstone design course instructors point out additional similarities in their courses[15]. Over half (57%) of capstone engineering design courses are yearlong. Most (88%) use team projects. Over one-third (37%) of capstone course instructors assess all 11 ABET Engineering Criterion 3 outcomes in their courses, but importantly, over half (56%) believe that their courses can assess achievement of all 11 outcomes. Further, Davis et al. claim that universal capstone design course outcomes can be defined based on the TIDEE profile of a top quality engineer[17].

For broad adoption, capstone design course assessments must be practical and add value. They will not disrupt, but enhance achievement for students of all backgrounds. They must not introduce gender or ethnic bias. They must be applicable in a wide range of disciplines and institutions, and be adaptable to inherent disciplinary differences among capstone courses. They must be easy to use and score. Results must accurately depict student achievement in design product quality, team and individual knowledge, and process performances.

GOAL AND OBJECTIVES

Goal

The goal of this project is to produce versatile, sound classroom assessment instruments for assessing student achievement in capstone engineering design courses. Upon completion of this project, capstone course instructors will have practical tools that accurately document student performance while causing minimal disruption to class activities and requiring minimal faculty time and training.

Objectives

Five objectives identify substantive achievements central to reaching the project goal:

1. Develop a capstone engineering design course assessment framework to organize and guide the addition of capstone course assessment instruments applicable across engineering disciplines.
2. Establish requirements for specific capstone design course assessment instruments that meet needs of varied institutions, disciplines, and course configurations in the US.
3. Create a set of assessment instruments for measuring student performance in capstone engineering design courses nationally.
4. Conduct pilot tests to demonstrate versatility and value of assessment instruments for diverse capstone design courses and students.
5. Produce support materials that enable rapid adoption of assessment instruments for additional capstone design courses.

PROJECT PLAN

Three primary groups will contribute to this project: (a) Development Team for project leadership, (b) Project Consultants for expert advice in key areas, and (c) Implementation Team for classroom implementation. Group definitions and memberships are presented in the Personnel section of this proposal. The project Development Team will lead project activities and strategically draw on the other primary groups throughout the project.

The engineering design process orders project steps to create high quality classroom assessment instruments within the allotted time. As seen in the left column of Figure 1, the design process begins with a need and ends with a creative, valuable solution. Moreover, important stakeholder needs direct the "design." Step 1 is the determination of stakeholder needs and expectations for assessment instruments. In step 2, needs are processed to establish a framework for organizing assessment instruments and to produce a set of requirements for quality capstone design assessment instruments. In step 3, numerous performance tasks are identified as possible contexts for assessing student achievement. In step 4, the "best" performance tasks are selected (based on the requirements established in step 2) as nuclei for assessment instruments to be developed. In step 5, the selected instruments are created with refined performance tasks and scoring rubrics for each task. In step 6, the instruments are tested to determine how well they meet established requirements. Finally, the assessment instruments are refined, packaged, and disseminated for broader adoption and use. As is common in engineering design, steps will be repeated as necessary to improve the process and the assessment instruments.

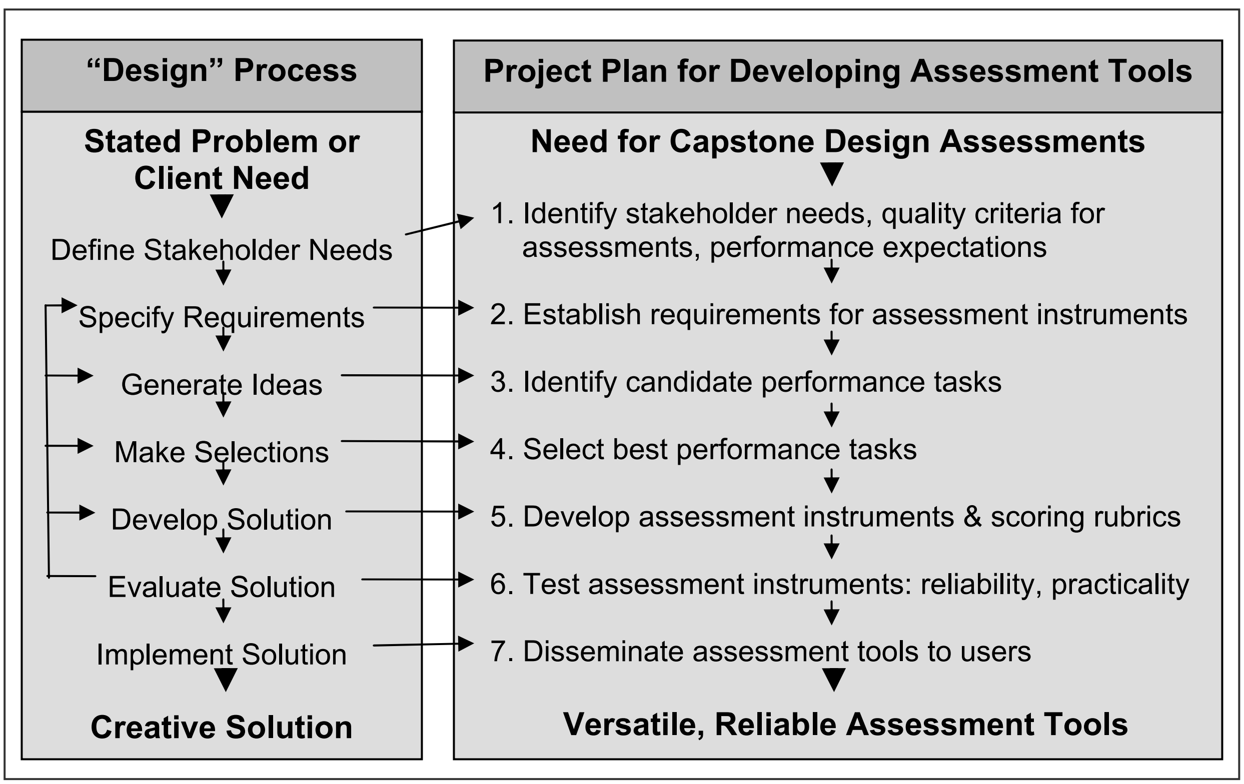

Figure 1: Project plan presented as product development or "design process"

TERMINOLOGY

In this project proposal, we use the terminology and definitions of Table 1 for consistency.

Table 1: Definition of assessment terminology

Outcome: Result of a learning experience or performance
Assessment: Results of measurement of student performance
Assessment Instrument: Questions or instructions administered to obtain student response
Assessment Tools: Resources that support development or use of assessment instruments
Performance Task: A context or assignment in which performance is observed
Performance Criterion: A focus area for observing quality in a performance
Performance Factor: One-dimensional source of variability within a focus area
Performance Measure: A scale for quantifying achievement for a performance factor
Performance Standard: Target level for a performance

The seven (numbered) steps of the project plan (shown in Figure 1) are discussed in the following sections.

Steps 1 & 2: Stakeholder Needs & Assessment Requirements

High quality assessments address needs and concerns of important stakeholders. For capstone design assessments, stakeholders include: faculty, students, and employers of engineering graduates. The assessment community calls for quality assessments that measure intended performance in appropriate ways and avoid bias or distortion. According to Stiggins, quality assessment must satisfy five conditions (listed in the left column of Table 2): clear purposes, clear achievement targets, proper methods, appropriate sampling, and bias elimination[45]. Therefore, capstone course assessment instruments will be developed with the attributes listed in the right-hand column.

Table 2: Principles for quality assessments as applied to capstone courses

Quality Principles	Attributes of Proposed Capstone Assessment Instruments
Have clearly articulated purposes	Purposes: Feedback; summative assessment (or evaluation) of individual and group achievements; suitable for use in grading
Have clear and appropriate targets	Targets: Performance standards set within performance measures that span undergraduate performances
Match the method to the target	Methods: Performance tasks selected from common capstone assignments to fit type of outcome being measured
Sample performance appropriately	Sampling: Regular capstone class activities in which all students participate
Eliminate bias and distortion	Bias: Test with diverse students and instructors at varied institutions and revised as needed to remove bias

Before developing assessment instruments, a capstone engineering design course assessment framework will be developed for organizing assessment instruments to fit varied engineering disciplines and courses. The framework will enable one to catalog, retrieve, adapt, and develop instruments so others can utilize them in specific capstone course environments. As shown in Figure 2, learning outcomes will be an important parameter in a framework that enables selection of assessment instruments for a given capstone course. This framework will be especially valuable to instructors of capstone design courses because, for their unique course, discipline, and institutional conditions, they will be able to identify instruments for the student learning outcomes of interest to them.

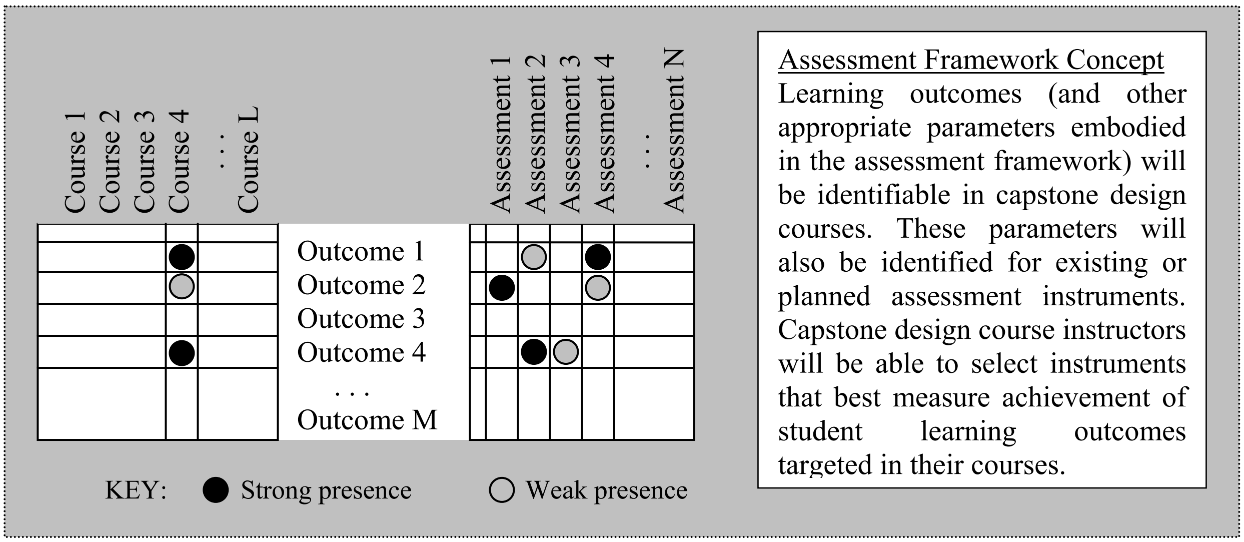

Figure 2: Framework linking assessment instruments to courses through learning outcomes

Two types of assessment requirements will be established for capstone design courses: student learning outcomes and operational issues for assessment instruments. Stakeholders providing input include capstone engineering design course instructors, students, and employers of engineering graduates.

Capstone engineering design course instructors across the nation will be surveyed to establish an initial set of requirements for assessment instruments. Representative input will be obtained by segmented sampling of engineering programs according to discipline and type of institution (including minority institutions). Instructors will be selected from McKenzie's 150 identified collaborators and others added from membership of the American Society for Engineering Education (ASEE) to reach the desired sample mix[15]. Sampled instructors will be presented learning outcomes derived from the TIDEE profile of a top quality engineer and other sources (see Supplementary Documentation). Respondents will rate an outcome according to its importance to their discipline and its importance to engineering as a whole. They will also rate importance of operational issues to capstone assessments. Example requirements – performance criteria and operational features – are presented in Table 3.

Table 3: Example requirements for capstone design course assessment instruments

Performance Criteria	1. Students encountering a problem explore all factors relevant to understanding the problem situation 2. Students developing problem solutions establish requirements and plan solution efforts that address key issues, within accepted constraints 3. Students generate many, varied, and unusual approaches to solutions 4. Students establish trust, understanding, and shared vision with key stakeholders 5. Students self-assess and improve their performance individually and as a team
Operational Features	1. Assessments fit frequently used assignments in capstone design courses. 2. Time required for scoring an assessment is not more than for normal grading. 3. Performance criteria lead to objective measures of student achievement. 4. Assessments can be used to document achievement of ABET EC 3a-k outcomes 5. Assessments provide data for assigning individual student grades.

Student input will be obtained from focus groups assembled at institutions of Implementation Team members, where assessment instruments will be pilot tested later in the project. Institutions and disciplines are listed under Steps 6 & 7. Students will be asked to rate importance of assessment instrument features to their successful completion of assessments. Features to be rated include: individual vs. team assessment, type of response required (essay, list, etc.), relationship of assessment to project assignment, and how results will be used.

Employer input will be obtained from members of the Corporate Member Council (CMC) of the American Society for Engineering Education (ASEE). Members will be selected to represent different business sectors across primary engineering disciplines. Those surveyed will be asked to validate the outcomes previously rated by capstone course instructors. The chair of the CMC has committed to supporting this activity (see letter in Supplementary Documentation).

The project Development Team will lead in the definition of assessment requirements, using previously mentioned stakeholder input. First, they will assemble and synthesize stakeholder input (described above) to prepare an initial draft. Then they will convene Project Consultants to review and refine the requirements. Finally, the DT will route the requirements to faculty, students, and employers to check their validity before finalizing the assessment requirements list.

Deliverables:

- An established capstone engineering design course assessment framework accommodating widely varied course and assessments
- Established requirements for successful capstone design course assessments in varied institutions, disciplines, and course configurations in the US.

Steps 3 & 4 & 5: Performance Tasks and Assessment Instruments

A set of three assessment instruments will be developed and tested in this project. From past experience of the TIDEE project team, three assessment instruments can be developed within the scope of this project, and three can address most of the ABET Engineering Criterion 3 outcomes. To augment its versatility, each instrument will be developed around a commonly-used performance task in capstone engineering design courses.

Three performance tasks will be selected as nuclei for the assessment instruments. This process begins by identifying a wide range of performance tasks that elicit desired high-level integrated student responses in capstone engineering design projects. Development Team members will compile lists from their own experiences, from McKenzie's survey[15], and from brainstorming sessions. Examples of performance tasks already being used by DT members to gather evidence of capstone design course outcomes achievement include:

- **Written Research Report:** Individual draws project-related information from numerous sources, critically analyzes findings, and applies results to the project
- **Project Management Plan:** Team defines organizational structure, member responsibilities with accountability, communication protocols, and a timeline with major milestones
- **Project Proposal:** Team presents project scope and rationale, design requirements, a plan for quality assurance, and a project budget with financial justification
- **Reflective Growth Paper:** Individual identifies areas of needed professional growth, steps taken to achieve growth, and success and impacts of growth on team performance
- **Client Design Review:** Team organizes and conducts client meeting, makes formal oral presentation on project activities and achievements, and responds to client questions
- **Written Design Report:** Team presents project results, including background, project goals, design requirements, crucial methods and decisions, testing, analysis, and design details.

For greatest project value, the performance tasks will be selected so that:

(a) Multiple performance criteria will be addressed by one well-planned performance task,

(b) Difficult-to-assess outcomes from ABET Engineering Criterion 3 will be addressed, and

(c) Selected performance tasks fit into most capstone engineering design courses.

Assessment instruments must comply with requirements established in Steps 1 & 2. Table 4 presents a method for scoring proposed tasks against student performance criteria and assessment instrument operational features. The tasks scoring the most total points while also addressing criteria a-c (above) will be strongly considered for development into assessment instruments.

Table 4: Method for rating performance tasks by assessment requirements

	Assessment Requirements				
	Performance Criteria			Operational Features	
Performance Tasks	Explore factors fully	Create valuable solutions	Establish stakeholder relationships	Assignment common to capstone	Scoring time not excessive
Client design review	2	2	3	2	2
Written research report	3	2	1	2	2
Reflective growth paper	2	1	2	1	2

Each assessment instrument will include materials for students and materials for the instructor. The instrument given to students will explain its purpose, give instructions for completing the performance, and present criteria used for scoring. The instructor will receive performance measures for scoring student work. Scoring scales will span the range of performances expected in capstone engineering design courses. As appropriate, decision rules will be developed to enhance inter-rater reliability. (See Supplementary Documentation for scoring scale examples.)

Assessment instruments will be developed with input from three primary groups. The Development Team will assemble initial lists of performance tasks and performance criteria based on relevant literature and personal experience. Project Consultants will be convened to refine lists, select and refine performance tasks, and draft performance measures. Then, DT members will synthesize results and develop the first full draft of each assessment instrument. These will be reviewed by Project Consultants and Implementation Team members.

Deliverables:

- Performance tasks for eliciting desired student performance in capstone engineering design
- Assessment instruments for measuring student performance in capstone design courses

Steps 6 & 7: Pilot Test and Disseminate Assessment Instruments

A set of diverse testing environments will be used to evaluate the versatility and reliability of the assessment instruments. The Development Team will use these instruments one term in their capstone courses to identify assessment and implementation issues for final refinements. Then they will work with the Implementation Team to define implementation strategies for the testing period (academic year 2006-2007). The DT will assist the Implementation Team in integrating the assessment instruments into their capstone design courses and in gathering test data.

Capstone design courses have been chosen to test the assessment instruments under widely varying conditions. Table 5 identifies sites for DT pre-testing (**bold)** and for subsequent IT testing *(italics)*. Sites include diverse disciplines across both private and public institutions, which encompass traditional and minority student populations. Some disciplines are replicated to determine institutional effects. Design project duration ranges from single semester to academic year. Project types include industry-sponsored, research-driven, appropriate technologies in developing countries, and entrepreneurial product development. Although the test sites are not all-inclusive, the breadth of testing will determine adaptability issues for the instruments.

Table 5: Sites for the testing of assessment instruments for capstone design courses

Institution	Type; Carnegie Foundation Classification	Program(s)*
Washington State University	Land grant; Doctoral/Research Universities—Extensive	**BE**, *ME,ChE, EE/CptE, CE*
University of Idaho	Land grant; Doctoral/Research Universities—Extensive	**ME**, *ABE, ECE*
Seattle University	Private; Master's Colleges and Universities I	**CE**, *ME, EE/CptE*
Tuskegee University	HBCU; Master's Colleges and Universities I	**ME**, *ChE*

* **Bold** programs are pre-test sites; *italics* are implementation test sites; **bold** sites included both times.

Assessment instruments will be evaluated for their ability to provide useful measures of student performance and for their user-friendliness. The usefulness of data will be evaluated in two ways: consistency in scoring and match with other indicators of performance. Samples of student work will be scored by multiple instructors, and inter-rater reliabilities will be calculated to quantify scoring consistency. Assessment scores will be compared to instructor, student, and project sponsor ratings of the same performance factors to determine scoring validity. User-friendliness will be evaluated by conducting surveys of faculty who have implemented the assessment instruments. Surveys will address issues of integration into classes, understanding assessment expectations, and scoring. Both instructors and students will be surveyed.

The Development Team will conduct user surveys and analyze survey results. Results will be analyzed to determine effects of discipline and institution on assessment acceptability. Results will identify strengths and improvements needed in assessment instruments and their administration. Results will drive refinements to produce assessment packages for broad dissemination. Assessment instruments, scoring scales, and operational tips will be posted on the TIDEE web site. An assessment manual will be prepared as a companion for engineering design texts to support effective implementation of assessment instruments in capstone design courses.

Deliverables:
- Test data that demonstrates versatility and value of assessment instruments.
- Assessment packages to support effective adoption of assessment instruments.

PROJECT PERSONNEL

Development Team

The Development Team provides leadership for the project and forms the interface with primary collaborating institutions. This team develops project materials, solicits input from Project Consultants, and advises Implementation Team members during use and testing of assessment instruments. The Development Team includes the project PI and Co-PIs from each of the primary contributing institutions. Member contributions are summarized in Table 6 and described in the following paragraphs.

Table 6: Development Team members and affiliations

Name/Role	Discipline/Institution	Expertise/Responsibilities
Denny Davis, PI	Bioengineering, Washington State Univ.	Project director; leads assessment tool devel. & testing; coordinates WSU efforts
Michael Trevisan, Co-PI	Assessment & Evaluation, Washington State Univ.	Leads project assessment & evaluation; guides in design of assessment system
Phillip Thompson, Co-PI	Civil Engineering, Seattle University	Tests/facilitates assessment at SU; contributes to development of assessments
Steven Beyerlein, Co-PI	Mechanical Engineering, University of Idaho	Tests/facilitates assessment at UI; contributes to assessment tools
Kunle Harrison, Co-PI	Mechanical Engineering, Tuskegee University	Tests/facilitates assessment at TU; contributes to assessment; facilitates minority perspectives

Dr. Denny Davis, PI

Dr. Davis, has directed the TIDEE consortium that produced reliable design assessment instruments. He teaches a capstone design course with multidisciplinary product development teams and has created a number of performance tasks suitable for development into assessment instruments. He worked with capstone instructors and companies nationally to define the profile of a top quality engineer. He is a Fellow of ASEE. His contributions to engineering education and minority programs have been recognized by numerous local and national awards.

Dr. Michael Trevisan, Co-PI

Dr. Trevisan is director of the WSU Assessment and Evaluation Center. He has provided evaluation expertise on several NSF funded projects at WSU and collaborated with Drs. Davis and Beyerlein on previously funded work. He has numerous publications in assessment and evaluation and presents regularly at national meetings. He is sought after throughout the state for evaluation assistance and expertise. Dr. Trevisan oversees a doctoral program in educational evaluation and teaches courses in applied statistics, measurement, and program evaluation.

Dr. Phillip Thompson, Co-PI

Dr. Thompson is associate professor of Civil & Environmental Engineering at Seattle University and has supported SU's Engineering Capstone Project Center for seven years. He has worked with the TIDEE consortium for three years and used TIDEE tools to assess design team readiness for freshmen and seniors. Dr. Thompson has also helped disseminate TIDEE tools via publication and regional and national engineering education seminars.

Dr. Steven Beyerlein, Co-PI

Dr. Beyerlein serves as coordinator of the Mechanical Engineering capstone design program at the University of Idaho. This program, featuring yearlong industry-sponsored design projects, is facilitated by graduate student mentors highly trained in design methods, manufacturing practices, and engineering leadership. The scope and outcomes of projects over the last seven years are illustrated at http://seniordesign.engr.uidaho.edu. Dr. Beyerlein has worked closely with Drs. Davis and Trevisan on the development and testing of the Design Team Readiness Assessment and has contributed to regional and national workshops on outcomes assessment.

Dr. Olakunle Harrison, Co-PI

Dr. Harrison is associate professor of Mechanical Engineering at Tuskegee University and is a lead faculty member in engineering design. He serves as the PACE (Partnership for the Advancement of CAD/CAM/CAE Education sponsored by GM, EDS, Sun, HP, and Mechanical Dynamics) advisor. Dr. Harrison teaches capstone design and automotive systems design. He is instrumental in moving the capstone course towards a multidisciplinary team setting. He has worked extensively with pre-college and freshman preparatory programs at two universities.

Project Consultants

Project Consultants bring added perspectives to ensure that project developments are sound and valuable for enhancing engineering education into the future. The individuals listed in Table 7 provide expertise in learning theory, engineering and design education, design assessment, and workforce needs. Letters of commitment are included in Supplementary Documentation.

Table 7: Project consultants and expertise they bring to the project

Name	Affiliation	Expertise
Robin Adams	University of Washington, Center for Engineering Teaching and Learning	Design learning theory, pedagogy, and assessment
Patricia Brackin	Rose-Hulman Institute of Technology, member of Foundation Coalition	Program assessment, engineering design assessment
Norman Fortenberry	Director, Center for Advancement of Scholarship in Engineering Education, National Academy of Engineering	Engineering education needs for the future
Isadore Davis	Raytheon; Chair, ASEE Corporate Member Council	Workforce needs in corporate America
Judith Sims-Knight	University of Massachusetts – Dartmouth	Cognitive development in engineering design education
Durward Sobek	Montana State University, Industrial Engineering	Portfolio assessment in capstone engineering courses

Implementation Team

The Implementation Team is comprised of capstone engineering design course instructors. Under direction of DT, these and possibly other capstone course instructors at their institutions will implement and test the assessment instruments during the third year of this project. They will score their students' assessments and make scores available to the DT for inter-rater reliability analysis. They also will provide feedback on assessment instrument operational issues. Implementation Team members and their affiliations are presented in Table 8.

Table 8: Implementation Team members and affiliations

Name	Institution	Discipline
Charles Pezeshki	Washington State University	Mechanical Engineering
Rollin Hotchkiss	Washington State University	Civil Engineering
Jose Delgado-Frias	Washington State University	Computer Engineering
Richard Zollars	Washington State University	Chemical Engineering
Bob Cornwell	Seattle University	Mechanical Engineering
Al Moser	Seattle University	Electrical/Computer Engineering
Tom Hess	University of Idaho	Agricultural/Biological Systems Engineering
Herb Hess	University of Idaho	Electrical/Computer Engineering
Nader Vahdat	Tuskegee University	Chemical Engineering
Hsing Hsiao	Tuskegee University	Mechanical Engineering

PROJECT TIMELINE

This is a 40-month project, spanning May 2004 through August 2007, as shown in Figure 3.

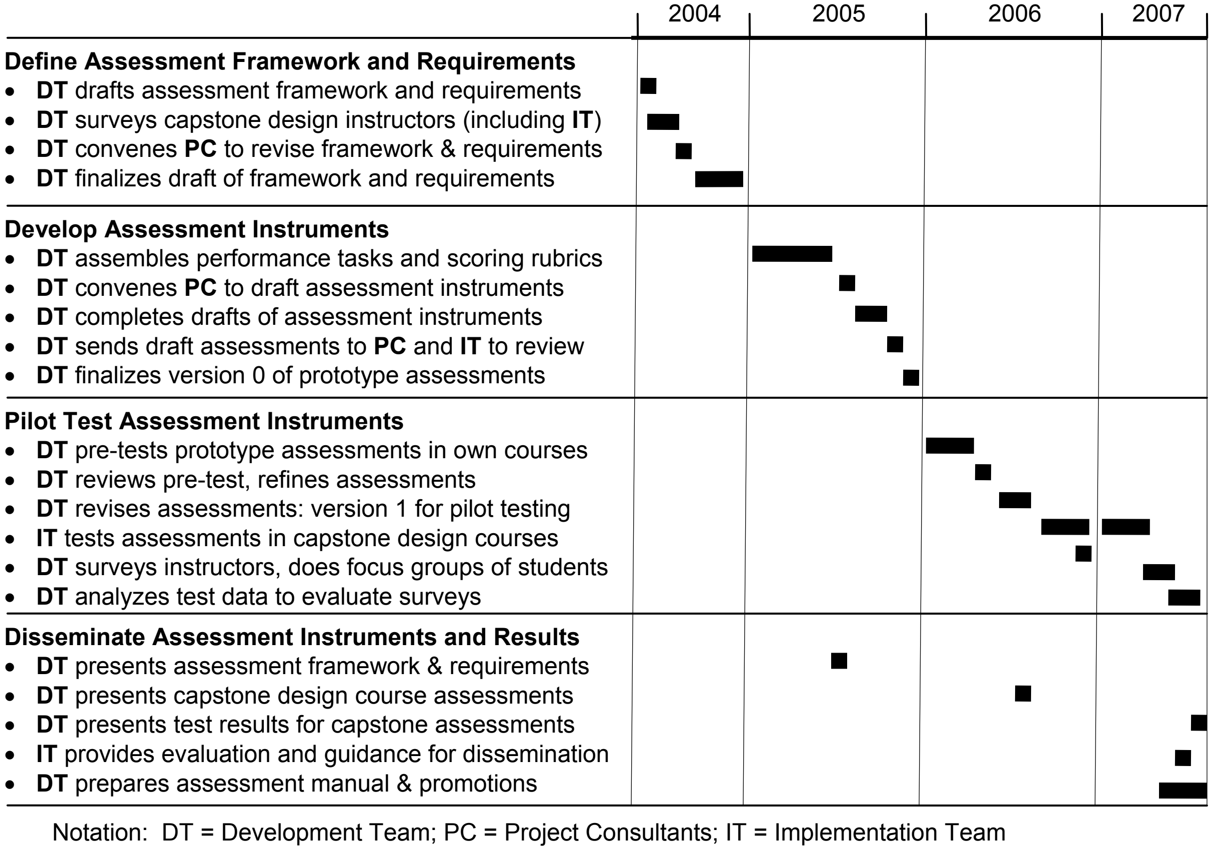

Figure 3: Timeline for developing capstone engineering design assessments

PROJECT EVALUATION

Project evaluation will be conducted by the Assessment and Evaluation Center (AEC) at Washington State University. Led by Dr. Trevisan, the AEC has many years experience conducting evaluations for NSF funded projects, particularly grants in engineering education. Components of the evaluation include implementation evaluation, formative evaluation, and summative evaluation. (See Table 9.)

Implementation evaluation focuses on the extent to which the project infrastructure is established as planned. Under facilitation of AEC staff, project leadership will examine budgets, personnel, and timeline to ensure that necessary infrastructure is implemented as planned. Periodic meetings with the DT will ensure proper oversight of these project aspects.

Formative evaluation provides feedback to project leaders regarding the ongoing operation of the project. AEC staff will conduct periodic review meetings with project personnel to determine what is going well and what needs improvement. Meetings, questionnaires, and interviews will be utilized to determine if mid-course corrections are needed to achieve project outcomes.

Summative evaluation will focus on the extent to which project outcomes were met and identification of any unintended outcomes as a consequence of the project. To this end, AEC staff will periodically review products developed, conduct meetings with project staff, administer questionnaires to stakeholders concerning satisfaction with the assessments, and interview project stakeholders concerning the usefulness of the assessment instruments.

Table 9: Evaluation matrix for the project

Evaluation Question	Responsible	Method	Timeline
Implementation Evaluation			
1. Are budgets & personnel in place?	DT & AEC	Meetings	First year
2. Have activities started as planned?	DT & AEC	Meetings	First year
Formative Evaluation			
1. What is going well?	AEC staff	Interviews, questionnaires	Periodically
2. What needs improvement?	AEC staff	Interviews, questionnaires	Periodically
Summative Evaluation			
1. Were objectives met?	AEC staff	Interviews, document review	Project end
2. Were stakeholders satisfied with the products?	AEC staff	Interviews, questionnaires	Project end
3. Were unintended outcomes obtained?	AEC staff	Interviews, questionnaires	Project end

SUMMARY OF PROJECT MERITS

Intellectual Merit

- A framework will be established for expanding classroom assessment instruments for capstone engineering design courses.
- Classroom assessment instruments will be developed with expert input and will be tested in diverse settings to prove instrument versatility, reliability, validity, and user-friendliness.

Broader Impacts

- Assessment instruments will be applicable in engineering capstone courses at widely differing institutions and in different capstone course models nationally.
- Proven assessment instruments will enable engineering programs to improve student learning and align student preparation with national engineering workforce needs of the future.

Integration of Research and Education

- Research on adult learning, engineering design education, and assessment will inform development and testing of classroom assessments for capstone design courses.
- Workforce education needs of the future, cognitive development in design education, and existing assessment tools will be incorporated into development of new assessments.

Integrating Diversity into NSF Programs

- Diverse perspectives will be used to guide development and implementation of assessment instruments that avoid bias due to gender, sociological, or ethnic backgrounds.
- Assessment instruments tested in diverse classroom settings and among diverse student populations will ensure their value for measuring and enhancing learning for all engineering students.