IDEALS for Professional Skills Achievement and Assessment

Denny Davis[1], Steven Beyerlein[2], Michael Trevisan[1], Phillip Thompson[3], Susannah Howe[4], Howard Davis[1], Jay McCormack[2], Patricia Brackin[5], Javed Khan[6], Paul Leiffer[7]
[1]Washington State University
[2]University of Idaho
[3]Seattle University
[4]Smith College
[5]Rose-Hulman Institute of Technology
[6]Tuskegee University
[7]LeTourneau University

The Integrated Design Engineering Assessment and Learning System (IDEALS) offers web-based assessment and instructional resources (modules) that enable students to achieve outstanding work-ready professional skills (teamwork, professional responsibility, and self-directed learning) in their capstone design project experiences. Instructors using IDEALS resources intersperse learning exercises with formative assessments to grow students' abilities in self-reflection while documenting targeted professional skills. Summative assessments provide multi-faceted evidence of students' knowledge and performance of these professional skills, as needed for awarding grades and for documenting student outcomes for program accreditation. IDEALS resources may be used individually for instructional or assessment purposes, or in sequences that systematically lay foundational knowledge, test and revise understanding, and deepen knowledge in a learning situation that mirrors the professional work environment – resulting in instructionally relevant measurement of professional skills.

Through a yearlong pilot testing period in seven diverse institutions and disciplinary settings, IDEALS modules have been shown effective for developing and documenting achievement of professional skills. Assessments regularly apprise instructors of issues needing attention so that interventions can maximize student learning and performance. Students learn how to better self-assess, perform as professionals, and grow skills needed for effective teams and productive contribution to their projects. Both students and faculty recognize that the time invested in professional skills development, supplanting some time-on-task on their projects, does produce skills valuable in the professional workplace and indirectly enhances the quality of their project deliverables.

Corresponding Author: Denny Davis, davis@wsu.edu

What is IDEALS?

How can an engineering program confidently develop and document students' professional skills? Authentic professional skills are acquired in settings in which learners engage in activities distinctive of the profession under the guidance of an expert in the profession[1]. Thus, capstone design courses can become environments for apprentice-like learning of professional skills[2, 3]. To this end, capstone instructors need to create and facilitate learning experiences that systematically transition from the instructor showing and explaining, to instructor watching and coaching, to learner demonstrating and extending skills learned.

The Integrated Design Engineering Assessment and Learning System (IDEALS) structures professional skills learning in a capstone design project—a learning situation that mirrors the professional (e.g., industry) work environment. The system engages students in a six-step Initiate-Define-Explore-Assess-Learn-Show process, alternating learning and assessment to advance professional skills, while also teaching students to self-assess and take charge of their own learning[4]. IDEALS provides web-based assessment and instructional resources with proven facilitation strategies for teaching and assessing three professional skills vital to the engineering profession: teamwork, professional (and ethical) responsibility, and self-directed learning (professional development).

IDEALS Modules

IDEALS instructional materials and assessments are packaged as modules that are additionally grouped by the professional skills being developed. As shown in Table 1, four IDEALS assessments are available for teamwork, three for professional development, and two for professional responsibility. The earlier assessments

in each skills area are formative [F], focused on giving feedback for improvement. The last assessment in each skills area is summative [S], focused on measuring final achievement.

Table 1. IDEALS Modules for Professional Skills

Area	Assessment Name	Instructional Materials
Professional Development	Professional Development Plan [F]	Readings and in-class activities for Professional Development Plan and Professional Development in Progress
	Professional Development in Progress [F]	
	Professional Development Achieved [S]	
Professional Responsibility	Professional Responsibility Formation [F]	Readings and in-class activities for Professional Responsibility Formation
	Professional Responsibility Achieved [S]	
Teamwork	Team Contract [F]	Readings and in-class activities for Team Contract, Team Member Citizenship, Teamwork in Progress
	Team Member Citizenship [F]	
	Teamwork in Progress [F]	
	Teamwork Achieved [S]	

Instructional materials are provided for use in preparing students for formative assessments. A typical process for implementing a module includes:

- Pre-class reading and worksheet completion to orient each student to terminology and to identify personal issues related to the skills being developed
- In-class discussion around individual students' sharing of their understandings and issues; team drafting of responses for post-class assignment
- Post-class completion of IDEALS assessment, prescribed by the assessment either as a team or as individual member submittals

IDEALS resources (readings, worksheets, assessments, scoring rubrics, instructor guides) are available to the instructor at: http://ideals.tidee.org. The instructor makes assessment assignments online and students complete assessments online. The instructor then provides feedback online and the student retrieves feedback online. All assessment data is retained in a secure database for access by authorized instructors and students.

IDEALS Learning Outcomes

IDEALS professional skills learning outcomes (defined below) were derived from the engineer profile, abilities of successful engineering practitioners[5, 6]. Each outcome aligns with a student outcome defined by ABET Engineering Criteria for program accreditation[7].

IDEALS Teamwork Outcome: In project work, a team orchestrates diverse member contributions to team relationships, work done together, individual work, and information management that achieve desirable team performance and productivity.
[ABET (3d): an ability to function on multidisciplinary teams]

Teamwork skills are developed by a structured three-module series anchored by the corresponding formative assessments: planning team operations (Team Contract), coaching members on their contributions to the team (Team Member Citizenship), and reviewing the team's procedures in the light of their contract (Teamwork in Progress). Twelve types of member contributions and twelve team processes prompt student thinking about desirable member contributions and processes. This series prepares students to show in the summative Teamwork Achieved assessment what they know and have done as evidence of being a high performing team.

IDEALS Professional Development Outcome: While engaged in a challenging project, an individual identifies needs for professional development (in technical, interpersonal, or individual attributes), sets relevant personal development goals, self-assesses, and documents progress and appreciation for professional development.
[ABET (3i): a recognition of the need for, and an ability to engage in life-long learning]

Professional development skills are grown by a two-module series anchored by corresponding formative assessments: Professional Development Plan and Professional Development in Progress. The first module guides students to identify a skill that is important to develop to benefit the team or project. Twelve skills (analyzing information, solving problems, designing solutions, researching questions, communicating, collaborating, relating inclusively, leading others, practicing self-growth, being a high achiever, adapting to change, and serving professionally) are offered for consideration. The student selects a skill and defines a plan for growing this skill. In the second module, the student reviews progress and modifies the plan for skill development. The summative assessment, Professional Development Achieved, asks the student to present

evidence of skill development achieved and learning that enables professional development in the future.

Professional Responsibility Outcome: In a project with diverse stakeholders, an individual accepts professional and ethical challenges, considers impacts of possible actions, and acts responsibly in concert with professional codes and ethical norms.

[ABET (3f) an understanding of professional and ethical responsibility]

Development of professional responsibility skills is facilitated by one IDEALS module and its formative assessment: Professional Responsibility Formation. In this module, each student is asked to consider his or her project responsibilities in seven areas: honest communication; financial responsibility; social responsibility; health, safety, well-being; property ownership; sustainability; and work competence. The student then selects a responsibility vital to the project and identifies steps to elevate his or her fulfillment of this responsibility in the light of applicable professional codes or ethical norms. The summative assessment, Professional Responsibility Achieved, asks the student to present evidence of his or her strong performance of a professional responsibility and to demonstrate an ability to address a challenging professional responsibility in the future.

IDEALS Module Implementation

IDEALS professional skills modules were developed in 2009-2010 under a National Science Foundation, Course, Curriculum and Laboratory Improvement program, type 1 grant, DUE 0919248. Modules underwent pilot testing in the 2010-2011 academic year to determine their effectiveness for facilitating and documenting professional skills achievement.

Module Testing

IDEALS modules were developed and tested in diverse settings to make them applicable in most engineering programs. As indicated by the author list, IDEALS modules were utilized at the following institutions: Washington State University, University of Idaho, Seattle University, Smith College, Rose-Hulman Institute of Technology, Tuskegee University, and LeTourneau University. Institutional culture and student demographics vary widely among these institutions that span private and public, co-educational and all-female, doctoral-granting and masters-granting, land grant, HBCU, and Christian identities. In addition, student participants represented disciplines including general engineering, mechanical engineering, civil and environmental engineering, bioengineering, chemical engineering, agricultural and biological engineering, electrical engineering, computer engineering, and several business and science disciplines.

Under this one-year testing period, faculty were allowed to implement IDEALS modules and parts of modules as they felt best fit their course and program objectives. One used only teamwork modules; one used no teamwork modules; others used a mix of modules from the different skill areas. Teamwork assessments were used most frequently, with Team Contract finding use five times, Team Member Citizenship ten, Teamwork in Progress three, and Teamwork Achieved five. Professional Development modules were used less frequently: Professional Development Plan was used six times, Professional Development in Progress twice, and Professional Development Achieved used nine times. Professional Responsibility modules, developed most recently, saw lowest use: Professional Responsibility Formation used twice and Professional Responsibility Achieved used three times. Varied implementations demonstrate how IDEALS modules can meet very different needs in capstone design courses.

Test Results

As IDEALS modules were implemented, they were being tested for their ease of use and the value they provided to students and faculty. Three sources of information were used to determine the impact and value of the modules:

1. Results from use of IDEALS modules in capstone design courses – student responses on assessments and instructor scoring of student responses
2. Interviews of instructors using IDEALS modules
3. Interviews of former students who used IDEALS modules a few months earlier

Evaluation questions and findings include:

- *How well do students develop targeted professional skills?* Students demonstrated good to very good abilities to explain and give evidence of the desired professional skills. They were able to describe strong performances and to explain how these impacted the team's performances. Students were only moderately good at coaching improvements of teammates and at detailing specific plans for improving their own professional skills. Students typically rated their own contributions to their team slightly higher than their teammates rated them on the same contributions. Students demonstrated significant growth in professional skills by the end of their projects, after they had been prompted in IDEALS modules to address these skills.
- *What can we learn about the development of professional skills?* Students tend to value the skills that they perceive to need in their project

context. They commonly see the need to grow their skills in communication, collaboration, solving problems, leadership, and design. They value skills for inclusiveness only after fragile team member relationships make this need clear. Similarly, they value design for sustainability when their specific project faces an obvious sustainability challenge. They value the ability of adapting to change when they personally experience the need for change. When students have identified a need for growing a professional skill, they typically are able to document growth in this skill after a period of project work with this skill in mind.

- *How do students value IDEALS modules?* Students acknowledge that they see activities focused on development of professional skills as distracting from their project work. However, after completing their project and experiencing professional work challenges, they recognize the direct value they gained from growing professional skills using IDEALS modules. They also recognize that this skill development indirectly enhanced the quality of their design products. Alumni identified moderate value gained from IDEALS modules; this value was enhanced when a series of modules was used in a single skill area. Using too many modules in a course, however, reduced the value gain perceived by students.

- *How do faculty value IDEALS modules?* Faculty saw value in IDEALS modules in a number of ways. First, the frequent assessment responses that reveal students' perceptions of challenges helped faculty intervene to solve problems and to enhance learning. Second, instructional materials were of high quality, and they helped prepare students both emotionally and cognitively to complete IDEALS assessments in ways that gave more accurate measures of knowledge and skills than had occurred without this preparation. Finally, IDEALS modules gave instructors multiple sources of information from which to assess students' learning processes and achievements. Faculty felt that the value gained offset the time that they and students invested in IDEALS modules.

Applications for IDEALS Modules

IDEALS modules are able to teach and assess professional skills valued in the engineering workplace. Modules are applicable to capstone courses with single discipline or multidisciplinary projects. Modules are suitable for projects that are client sponsored, entrepreneurial, competitions, or service oriented. The number of modules used in a project depends upon its duration. Full year projects may support use of all modules. However, best results occur when some modules are introduced in courses prior to the capstone design course. This brings students to the capstone course with proper orientation and better reflection skills so they benefit more and reach higher levels of professional skill achievement in the capstone course.

Maximum benefit from modules requires effective facilitation of learning activities, assessments, and feedback to students. Explaining expectations and showing high quality responses prepares students for fruitful assignments. Explaining how thoughtful responses benefit students professionally (preparation for engineering workplace) and in the class (affecting grades) serves to motivate serious responses. Prompt feedback reinforced by face-to-face comments helps increase student learning.

Capstone design course instructors interested in using IDEALS resources must be approved and issued an instructor account by the IDEALS project director. Approval is requested through a link at the bottom of the IDEALS website home page:
http://ideals.tidee.org.

References

1. Svinicki, M. D. A Guidebook on Conceptual Frameworks for Research in Engineering Education. http://cleerhub.org/resources/gb-svinicki
2. Collins, A.; Brown, J. S.; Holum, A., Cognitive apprenticeship: Making thinking visible. *American Educator* **1991**, (Winter).
3. Litzinger, T. A.; Lattuca, L. R.; Hadgraft, R.; Newstetter, W., Engineering Education and the Development of Expertise. *Journal of Engineering Education* **2011,** Volume 100, (Number 1).
4. Davis, D. C.; Trevisan, M. S.; Davis, H. P.; Beyerlein, S. W.; Howe, S.; Thompson, P. L.; McCormack, J.; Brackin, P.; Khan, M. J. In *IDEALS: A Model for Integrating Engineering Design Professional Skills Assessment and Learning,* American Society for Engineering Education Annual Conference, Vancouver, BC, 2011.
5. Davis, D.; Beyerlein, S.; Davis, I., Deriving design course learning outcomes from a professional profile. *International Journal of Engineering Education* **2006,** 22, (3), 439-446.
6. Davis, D.; Trevisan, M.; Davis, H.; Beyerlein, S.; McCormack, J.; Thompson, P.; Howe, S.; Brackin, P.; Leiffer, P.; Khan, M. J. *Integrated Design Engineering Assessment and Learning System (IDEALS): Piloting Teamwork and Professional Development Instructional Materials*; Pullman, Washington, November, 2011.
7. ABET *Criteria for Accrediting Engineering Programs*; Baltimore, MD, 2011.