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Alumni Perspective on Professional Skills Gained Through Integrated Assessment and Learning*

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Engineering professional skills are critical components of an engineer's performance in industry. Engineering professional skills include the ability to work in a team environment, awareness of and ability to contextualize engineering ethics, and an ability to establish and realize professional development goals. Engineering capstone design courses present the opportunity for an authentic learning experience with respect to complex, professional skills in situations similar to those in which they will be used in practice. The Transferable Integrated Design Engineering Education (TIDEE) consortium of engineering educators and researchers have developed and tested the Integrated Design Engineering Assessment and Learning System (IDEALS). IDEALS consist of nine modules with formative and summative assessments to guide and measure student learning of professional skills integrated with complementary instructional materials to facilitate use in project courses. Results from prior testing were positive from both student and faculty perspectives, but a key stakeholder—recent alumni users now working in industry—required further representation to determine IDEALS impact. A total of forty-two alumni that were recent users of the system completed the survey. 85%, 86% and 70% of survey respondents attributed enhancement in professional skills to the IDEALS teamwork, professional development, and professional responsibility modules respectively. Additionally, 82% of respondents reported some enhancement in terms of their reflective writing skills.

Keywords: professional skills; assessment; learning; IDEALS; teamwork; professional development; responsibility

1. The need for professional skills learning and assessments

An integral part of business management is framing goals and objectives for each unit that 'roll up' from specific and measurable goals at the employee level. Annual reviews are extremely important because, in addition to supporting business success, they affect employee pay, morale, attrition, and advancement. For this reason, employees and supervisors are asked to spend considerable effort reflecting on what was achieved and how it was achieved. Pre-

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ferably, this effort is distributed throughout the year, not restricted to once per year.

Especially prominent in annual reviews are engineering professional skills such as the ability to work in a team environment, awareness of and ability to contextualize engineering ethics, and an ability to establish and realize professional development goals. A by-product of the annual review exercise is the cultivation of reflective engineering practitioners who learn from and innovate amid engineering design and problem-solving challenges [1]. Both reflection-in-action and reflection-on-action are required to break out of communication and thinking logjams and move a team toward productive activity [2]. An engineering graduate who is proficient in reflection on professional skills will identify strengths, areas for improvement, and plans to realize improvement in project team dynamics, understanding of stakeholder perspectives and ethical concerns for the project. The reflective practitioner will be able to help plan team and personal developmental needs based on demands of a project, industry, or societal concern.

The challenge for engineering educators and educational programs is to confidently develop and document students' professional skills achievement to prepare the type of engineer called for by industry. 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 [3]. Engineering capstone design courses present the opportunity for an authentic learning experience with respect to complex, professional skills in situations similar to those in which they will be used. An authentic learning opportunity supports effectual assessment [4, 5] and learning. Thus, capstone design courses can become environments for apprentice-like learning of professional skills [6–7].

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 the student demonstrating and extending skills learned. However, many faculty members feel that they lack the information and know-how to develop assessments with clear and appropriate course objectives, and that can provide credible information for students and instructors to act upon. A majority of faculty members believe that assessment know-how is more important than ever, and that assessment training could be used productively to meet this need [5].

To address both the industry and faculty needs, the Transferable Integrated Design Engineering Education (TIDEE) consortium of engineering educators and researchers have developed and tested the Integrated Design Engineering Assessment and Learning System (IDEALS). IDEALS consist of nine modules with formative and summative assessments to guide and measure student learning of professional skills integrated with complementary instructional materials to facilitate use in project courses. The consortium reported on implementation and test results of the assessments from the IDEALS systems through a series of IJEE papers related to teamwork [8], professional development [9], and professional responsibility [10]. To complement these articles that contain student and faculty perspectives on the value of IDEALS, we surveyed current industry engineers, who were recent student users of IDEALS modules, about the value of the IDEALS modules from the perspective of the modern workplace. In this article, we provide an overview of IDEALS and an analysis of these findings.

2. The IDEALS system

2.1 Approach to learning

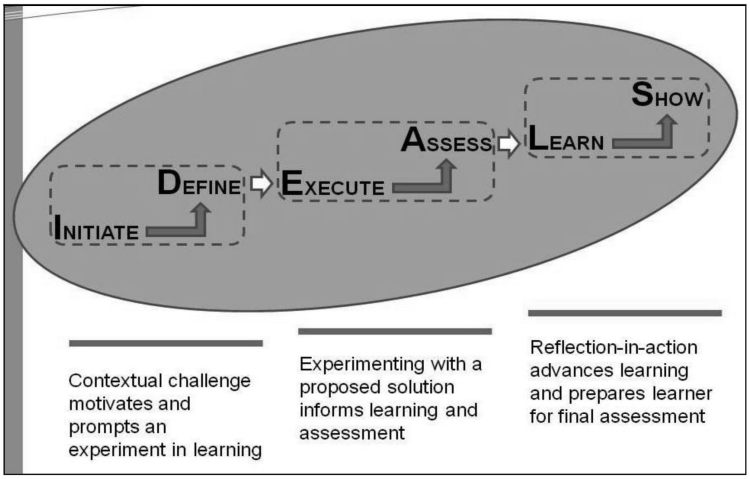
The Integrated Design Engineering Assessment and Learning System (IDEALS) was developed as part of NSF grant #DUE 0919248 by a team of engineers at Washington State University, University of Idaho, Rose-Hulman Institute of Technology, Smith College, LeTourneau University, Tuskegee University, and Seattle University, under the direction of Dr. Denny Davis, Emeritus Professor of Bioengineering at Washington State University. 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 (Table 1) process, alternating learning and assessment to advance professional skills, while also teaching students to self-assess and take charge of their own learning [11]. IDEALS provide web-based assessment and instructional modules 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) [12]. A distinguishing feature of each IDEALS assessment is an inventory of area-specific professional skills against which students self-rate their performance prior to writing about perceived strengths and areas for improvement.

2.2 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 2, four IDEALS assessments are

Table 1. IDEALS Learning Model for Team-Based Project Environments

IDEALS Model



Step	Example of Occurrence
INITIATE	A professional (e.g., teamwork, self-directed learning, ethical) challenge arises in the context of a team-based design project; this delays progress or limits performance.
DEFINE	Through formative assessment (planning), students assess the situation, define important needs, set goals, and create a plan for achieving strong performance.
EXECUTE	Students take action, in concert with team and project goals, to implement their plan toward achievement of strong processes and high quality work products.
ASSESS	Through formative assessment, students self-assess, peer-assess, or jointly assess progress toward goals and revise plans as needed to enhance achievements.
LEARN	As students implement their plans and think reflectively, they practice knowing-in-action and achieve results more characteristic of professionals.
SHOW	Through summative assessment, students document (show, explain, extend) their achievements in work products, skill development, and learning.

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. Assessments push students to think about and explain their knowledge, discuss their performance with peers, apply their learning to realistic professional challenges, build on and refine previous knowledge, analyze their own learning processes, and extend learning to new situations. Assessments reinforce definitions of learning targets and provide feedback on a student's progress toward these targets. Instructional materials are provided for use in preparing students for formative assessments, including analyzing an inventory of skills associated with each performance area. IDEALS resources (readings, worksheets, assessments, scoring rubrics, instructor guides) are available to the instructor at: http://ideals.tidee.org.

A module and/or assessment is selected by the instructor with the objective of either adding value to an ongoing course project or concluding an

Table 2. IDEALS Modules for Professional Skills

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

[F] denotes formative; [S] is summative.

Table 3. Typical process for using IDEALS modules in a course

Phase	Activities
Preparation	The instructor makes the assignment online. Also during the assignment preparation phase, students must be prepared to engage in the assessment. They need to know how this assignment relates to their success in the class and in professional life, and how to be successful in this assignment. Pre-class reading and worksheet completion are used to orient each student to terminology and to identify personal issues related to the skills being developed.
Implementation	During the assignment implementation phase, individual students share their understandings and issues of assignment-related concepts through in-class discussion. Additionally, discussions in class can shed light on personal benefits and on details of what constitutes a high performance on the assessment. IDEALS handouts and worksheets support this preparation. For team assignments, team members collaborate and draft responses to the assignment. Post-class, students respond to questions or prompts online and may also view rubrics that are used for scoring his/her responses. The instructor provides scores and written feedback online for the student. All assessment data is retained in a secure database for access by authorized instructors and students.
Follow-up	During the assignment follow-up phase, the student reads and cognitively processes online feedback from the instructor to gain maximum benefit. This includes individual students reading instructor scores and comments, followed by discussions of this feedback in the team or at the class level. In this way, students see how their responses aligned with those of others, which can modify his/her understandings to be more accurate. We have seen that students benefit from knowing what is expected, being motivated to do well, showing what they know in an authentic setting, and learning from personalized and prompt feedback. Programs can also compile the results of the assignment for accreditation purposes.

element of a project. A typical process for using a module includes preparation, implementation, and follow-up phases (Table 3) [13–14].

2.3 Learning outcomes

IDEALS professional skills learning outcomes (defined below) were derived from an engineer profile as well as abilities of successful engineering practitioners [15–16]. Each outcome aligns with a student outcome defined by ABET Engineering Criteria for program accreditation [17].

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.

The set of teamwork skills used to prompt written assessments focusing on this area is given in Table 4 [8].

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 that will 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

Table 4. Areas of performance used IDEALS Teamwork assessments

Performance Area	Contributions of Team Members
Team Relationships	Engages members with respect Demonstrates commitment Resolves conflicts constructively
Joint Achievements	Helps establish shared goals Follows plans to achieve team goals Works synergistically with others
Member Contributions	Delegates/completes tasks, as needed Performs competently to team standards Enables development in self and others
Team Information	Strives for fully-informed members Communicates well with external clients Documents achievements well

Table 5. Professional skills/attributes used in IDEALS Professional Development assessments

Area	Ability	Definition
Technical	Analyzing information	Applying methods/tools of analysis to understand and explain conditions.
	Solving problems	Formulating, selecting, and implementing actions for optimal outcomes.
	Designing solutions	Producing creative, practical products that bring value to varied stakeholders.
	Researching questions	Investigating, processing and interpreting information to answer important questions.
Interpersonal	Communicating	Receiving, processing, sharing information in many forms to achieve desired impact.
	Collaborating	Working with a team to achieve collective and individual goals.
	Relating inclusively	Valuing and sustaining a supportive environment for all knowledge and perspectives.
	Leading others	Developing shared vision & plans; empowering to achieve individual & collective goals.
Individual	Practicing self-growth	Planning, self-assessing, and achieving goals for personal development.
	Being a high achiever	Delivering consistently high quality work and results on time.
	Adapting to change	Being aware and responding proactively to social, global, and technological change.
	Serving professionally	Serving with integrity, responsibility and sensitivity to individual and societal norms.

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.

The set of professional development skills used to prompt written assessments focusing on this area is given in Table 5 [9].

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 (awareness and understanding of responsibilities) 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.

The set of professional and ethical responsibility skills used to prompt written assessments focusing on this area is given in Table 6 [10].

3. Classroom implementation history

Foundational versions of the IDEALS assessments underwent use, testing, and revision during the 2008–2010 academic years. The results of those implementations and tests were reported in a set of papers [8–10]. Following the development and testing of the assessments, complementary modules were developed in 2009–2010. Modules underwent pilot testing in the 2010–2011 academic year to determine their effectiveness for facilitating and documenting professional skills achievement.

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. Institu-

Table 6. Areas of responsibility used in IDEALS Professional Responsibility assessments

Area of Responsibility	Definition
Honest communication	Report work truthfully, without deception, with clarity to stakeholders.
Financial responsibility	Deliver products and services of realizable value and at reasonable costs.
Health, safety, well-being	Minimize risks to safety, health, and well-being of stakeholders.
Property ownership	Respect property, ideas, and information of clients and others.
Social responsibility	Produce products and services that benefit society and communities.
Sustainability	Protect environment and natural resources locally and globally.
Work competence	Perform work of high quality, integrity, timeliness, and professional competence.

tional 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.

During a one-year testing period, faculty were allowed to implement IDEALS modules or 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.

4. IDEALS impact from an industry perspective

Results from prior testing were positive from both student and faculty perspectives [8–10]. A key stakeholder, industry, required further representation to determine IDEALS impact. Industry input was used to define the assessments in the IDEALS system [15] in order to align with industry needs, with further testing to demonstrate whether IDEALS assessments met those needs. To test the impact of the IDEALS system, a survey was administered to alumni that were recent users of the system and who were currently practicing engineers. Although most respondents were employed less than one year, input from IDEALS alumni that were currently practicing engineers allowed for greater insight into the success of IDEALS at preparing engineers for industry positions.

Forty-two alumni from Washington State University, University of Idaho, Rose-Hulman Institute of Technology, Smith College, and LeTourneau University completed the survey. It should be noted when reviewing the data that the sample sizes for the survey were small; thus, it is necessary to examine the perceived differences and to carefully review the data when drawing conclusions. Yet, the data provide valuable insight into implications of the modules on professional practice. The respondents were asked to identify their current position. Responses included applications engineer, project manager, design engineer, process engineer, and quality engineer among others. Respondents reported that they held their current position for between a month and two years with the majority (26) reporting less than one year. The alumni were asked four quantitative questions in the survey.

1. To what extent did the IDEALS teamwork activities and assessments enhance your understanding of teamwork and grow your ability to perform effectively in future teams?
2. To what extent did the IDEALS professional development activities and assessments enhance your understanding of professional development and enable you to advance yourself professionally in future settings?
3. To what extent did the IDEALS professional responsibility activities and assessments enhance your understanding of professional responsibility and grow your ability to perform responsibly in professional settings?
4. To what extent did the IDEALS activities and assessments enhance your understanding of reflective practice and grow your ability to think reflectively about professional work?

For these questions, alumni could respond on a four point scale (*did not enhance, slightly enhanced, somewhat enhanced,* and *greatly enhanced*). Respondents also had the option to identify *not applicable* for questions concerning module types that they did not recall using. The responses to the questions (excluding those that did not recall using a module of that type) are found in Fig. 1. The countable responses for each question were 27, 14, 10, and 32 respective to the list of questions.

In addition to the quantitative aspect of the survey, respondents were asked for qualitative feedback. A summary of the qualitative responses is found in Table 7. Although most responses were positive, some respondents (approximately 12%) did not find the modules to be useful or to have an impact on their professional experience. These alumni felt the IDEALS materials were busy work and that the skills would be better learned through practical experience. One individual commented that he or she did not understand how the modules tied back into the senior design work. The same person commented: "*I don't think it helped us*

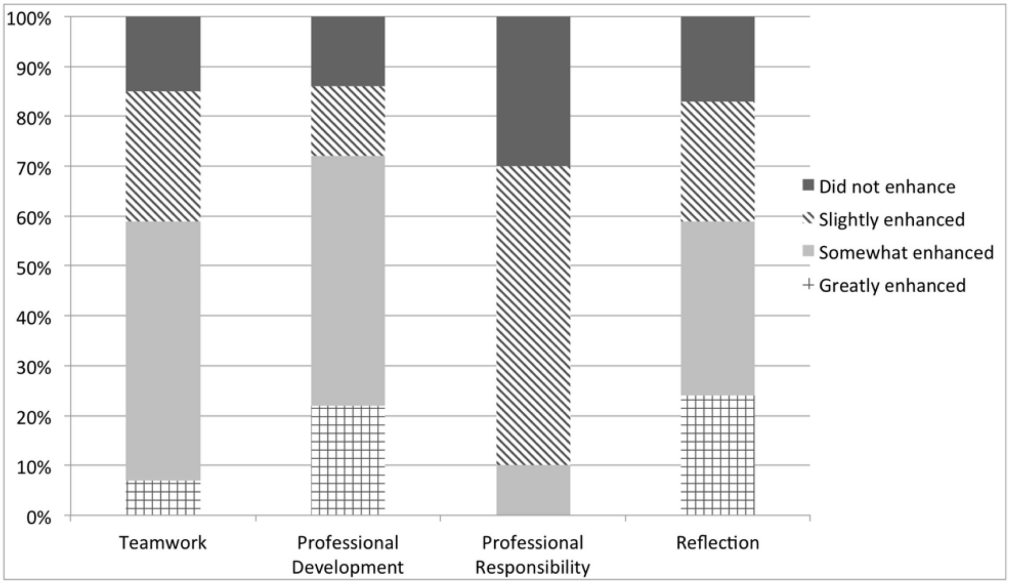


Fig. 1. IDEALS alumni survey responses. n = 42.

develop working (sic) in the real world.'' Notably, as mentioned in Table 7, several students felt the IDEALS modules did not play a role in their Professional Responsibility skill development.

Based on this finding, some may question whether professional responsibility and ethics can be taught. While further exploration is necessary to determine the answer, it should be noted that the goal of IDEALS is not to teach ethics or responsibility; rather, the objective is to teach students to recognize ethical issues and to increase understanding of their professional and ethical responsibilities as engineers. IDEALS does not necessarily impact students' decisions in those ethical situations, but the modules are designed to help students learn to identify such situations. Although some students did not attribute their professional responsibility skills to IDEALS, others mentioned that the modules made them more aware of their ethical and professional responsibilities, which was the intent of the modules. From a broader perspective, the issue could be one of transfer of knowledge. Student activities in the Professional Responsibility module are one form of active learning, in which skills learned in the module can be applied to a real-life setting. In the case of the IDEALS modules, particularly for Professional Responsibility, students are asked to transfer knowledge in a quasi-realistic setting to the real world of work. While the methods we use to follow up with alumni are logical and cost-effective, they could be improved to better capture evidence of transfer of learning for professional responsibility skills.

Finally, the survey allowed respondents to provide additional comments in order to improve IDEALS. Among the responses were the following comments:

- Make sure that you stress to students that employers will probably expect something similar from them and for those employers that don't, it is even more valuable because those students will form the future workplace.
- Improving the integration of IDEALS within group meetings and everyday work would make them more effective.
- Overall, I thought it was beneficial as is. I think it received the appropriate amount of attention to the point where it was beneficial but not overly time consuming. I got very valuable feedback from this and if students take it seriously it can have positive impacts on their upcoming careers.
- I think as time consuming as they were, they really were beneficial because they forced you to meet your teammates where they were at and prepare to engage with future co-workers.

5. Discussion

IDEALS modules are able to teach and assess professional skills valued in the engineering workplace. These professional skills include the ability to work in a team environment, awareness of and ability to contextualize engineering ethics, and an ability to establish and realize professional development goals. Based on the diverse environment in which modules have been successfully used, modules are applicable to capstone courses with single discipline or multidisciplinary projects and are suitable for projects that are client-sponsored,

Table 7. A summary of alumni responses to the qualitative survey questions

Question	Summary of Responses
Please describe how these assignments impacted your teamwork skills and if possible, illustrate with an example.	Participants felt the IDEALS assignments enhanced their communication skills and allowed them to give and receive constructive feedback to and from their peers. Several participants mentioned that the assignments allowed them to see their own strengths and weaknesses, as well as those of others. Participants also felt that the assignments increased their abilities to read people and to adjust their project goals as needed, based on the team dynamic and individual personality traits.
Please describe how these assignments impacted your professional development skills and if possible, illustrate with an example.	The IDEALS assignments helped students grow personally and professionally. For example, one participant felt the assignments helped them to step outside of their comfort zone. For another student, the assignments helped them better understand how they learn. For yet another, the assignments helped them learn *"to be upfront with the way I felt about my team and my project."* A couple of participants noted that the assignments demonstrated the value of feedback, and that this was reinforced in their workplace. One participant mentioned: *"Not two days into my first job's training I was briefed on the value of feedback, (with reference to company forms to highlight strengths, areas of improvement). I was glad to see this structure in place at my workplace as it promotes continuous improvement and a non-offensive culture."* Participants also mentioned that the assignments taught them how to assess team dynamics and evaluate individual contributions so that personal strengths could be drawn upon in a team setting. The assignments helped participants learn how to function better as a team member and to be more aware of their own strengths and weaknesses. Still, others felt the assignments had no effect or were not a good use of time. Overall, however, responses indicated the assignments were useful and positively impacted participants' professional development skills.
Please describe how these assignments impacted your professional responsibility skills and if possible, illustrate with an example.	Several participants noted that the professional responsibility skills were not addressed through the IDEALS assignments. One participant's comment summarized the sentiment: *"My professional responsibility skills improved considerably throughout the year; however very little or none of this was through the use of IDEALS. My feeling of responsibility to my teammates, school, and self were the primary drivers."* Those that were impacted by IDEALS felt that the assignments helped them to be more aware of and to better understand their responsibilities as a professional, to abide by deadlines, to speak with teammates directly about their commitment and contributions to the team, and to better understand real-life settings and the complexity of real-world situations. One person noted that the assignments helped them be a more reliable teammate. The participant noted: *"Teammates know that I will get something done when I say I will."*
Please describe how these assignments impacted your reflective practice skills and if possible, illustrate with an example.	The primary impact of the IDEALS assignments on participants was the benefit of self-reflection. As noted by one participant: *"It is very easy to get caught up in the moment. The IDEALS assignments forced the team to take a break from our work and reflect on our past."* In addition to reflection, participants thought the assignments taught them to respect their colleagues' opinions and acknowledge diversity, recognize team and individual strengths and weaknesses, and look back on past experiences to try to improve skills and accomplish greater things. In fact, one participant commented that: *"[the assignments] have helped me in being able to look back on my accomplishments and how [I] can do the same or even try to surpass them.* Participants gave examples of how they use these skills in their workplace. For example, one participant mentioned that *"They have impacted me to keep a reflective log at the end of each work day to track progress on improvements I am trying to make both in my technical skills as well as professional skills with coworkers."* Another person mentioned that: *"I'm always looking for ways to improve my skills. In particular, since I only graduated a year ago, I am constantly reevaluating what I do and don't like at my current job, so that I can determine what it is I want out of a job and can move myself in that direction."* Overall, self-reflection and self-awareness were key impacts of the assignments on participants' reflective practice skills.

entrepreneurial, competitions, or service-oriented. The number of modules used in a project depends upon its duration. Full year projects may support the use of all modules. However, based on the development team's experiences [13–14], 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, higher motivation for assessment, and better reflection skills so they benefit more and reach higher levels of professional skill achievement in the capstone course.

In previous implementations of the professional development and professional responsibility modules, user satisfaction was measured from post-assessment surveys of the instructors and students. For a teamwork-related module, student satisfaction was similarly measured. The results from the instructor surveys included strengths in identifying areas where students were struggling and excelling as well as generating important feedback for students. The results from the student surveys included strengths in trustworthiness of scores students received from instructors and value of the assignment to the success of the project. Details of these surveys in addition to other measures of quality can be found in [8-10]. The authors' most recent IJEE paper [10] notes that feedback from graduates in the first few years after graduation would be critical for indicating the benefits of IDEALS. This paper

investigates the perspectives of recent users of IDEALS modules who are engaged in professional engineering work. The survey results showed that 85% and 86% of alumni respondents attributed enhanced professional skills to teamwork and professional development modules, respectively. Although 70% of respondents attributed some enhancement in their professional responsibility understanding and abilities to the professional responsibility modules, the modules were only used in two settings which may have impacted the results. Additionally, 82% of respondents attributed to IDEALS modules some enhancement in their reflective skills, knowledge, and abilities applicable to professional settings. The positive comments from respondents often attributed value to an alignment of the modules with industry practice or to project settings, which was our objective. In particular, alumni mentioned the benefits of the modules in enhancing their communication skills, giving and receiving feedback, assessing team dynamics and evaluating individual contributions such that personal strengths could be drawn upon in a team setting, and identifying and understanding their responsibilities as professionals. The primary impact of the IDEALS assignments on participants was the benefit of self-reflection. As noted by one participant: *''It is very easy to get caught up in the moment. The IDEALS assignments forced the team to take a break from our work and reflect on our past.''*

Many participants offered suggestions for improving the IDEALS materials. Among the suggestions were: grouping team members' responses together to make it easier to compare team responses, allowing more time for reflection and evaluating team members' performance, conveying that employers will have similar expectations as what the modules provide, and replacing the assignment of percentages to work submissions with a scale to better capture individuals' contributions. These suggestions were consistent with instructors' observations about the need for effective facilitation to prepare students for reflective assignments [13–14] and were used to improve facilitation of the IDEALS modules the following term.

The research team acknowledges that IDEALS is not intended to impact professional skills in a vacuum. Rather, IDEALS is a catalyst for reflective thinking in the context of a project with respect to specific professional skills. An optimal balance of learning experience (the capstone project in this case), reflection on the experience, and reflection on the metacognitive process itself is necessary for maximum learner achievement. The Deming cycle [18] provides a relevant model for using IDEALS assessments in the continuous improvement of student professional skills. As in the Deming cycle, effective professional skills development requires effort in planning, doing engineering, checking results, and adjusting for the next cycle of professional activity. In the planning phase, students and instructors identify a professional skill area and examine subordinate skills such as those listed in Tables 4, 5 and 6.

This provides a seed for subsequent 'reflection-on-action' and for advanced practitioners can stimulate 'reflection-in-action'. Actual learning of professional skills requires a professional challenge in an authentic context. This comprises the 'doing' and consumes a large portion of students' effort. At key stages in the project, the student is prompted to check the progress of professional skill development. A variety of IDEALS modules provide formative feedback about professional skill development. While checking progress comprises only a fraction of the student's total effort on the project, the act of identifying strengths and formulating plans for improvement in professional skills provides an opportunity for personal growth, even if that growth is solely attributed to the project. Based on consideration of personal assessment, instructor feedback, and peer input, appropriate adjustments in attitudes, methods, and commitments surrounding reflective practice should be made before engaging in the next cycle of professional activity.

Although the sample size of the alumni survey was relatively small, the addition of these results to those reported in [8–10] provides valuable insight about the perceived value of IDEALS from student and faculty perspectives, and now from the perspective of new engineers working in industry. Together, the perspectives add depth to understanding the impact of IDEALS modules. For example, it is now clear that impact of the IDEALS modules on students' professional skills requires a combination of useful module content and effective integration of the modules into students' project work by instructors. For the most effective instruction to occur using the modules, faculty must illustrate the importance of targeted professional skills in engineering practice, explain expectations to students, show examples of high quality responses that will aid student growth, and offer meaningful feedback. Explaining how thoughtful responses benefit students professionally (preparation for engineering workplace) and in the class (contribution to grading) serves to motivate serious, reflective responses. In particular, prompt feedback reinforced by face-to-face interpretation and commentary helps increase student learning. In sum, the modules are consistent with Chickering and Gamson's Seven Principles of Good Practice in Undergraduate Education, as the modules (1) encourage student-faculty

interactions, (2) encourage cooperation among students, (3) encourage active learning, (4) give prompt feedback, (5) emphasize time on task, (6) communicate high expectations, and (7) respect diverse talents and ways of learning [19]. Thus, faculty can incorporate the IDEALS modules to benefit the student experience and to assist graduates in becoming more successful, reflective practitioners.

6. Conclusions

The IDEALS system is predicated on the hypothesis that truly successful people are self-motivated to update their skills and expand their skill sets within their area of expertise and into new areas. Engineering students may not often fit this profile because of their focus on the rigorous engineering curriculum. There is also a larger population (perhaps overlapping) of engineers that want to update and expand their skills sets but who lack a framework for realizing change. These populations stand to benefit most from exposure to IDEALS modules and completion of IDEALS assessments.

IDEALS modules yield the greatest benefits to students and to engineering programs when the modules are used as directed by the instructor's guide that accompanies each module. The modules include a pre-class activity that provides motivation and context for the professional skills being addressed. The in-class activities help students place the professional skills into the context of their current project and team and coach the students toward completion of tasks that are used in the post-class assessment. Instructors also need to explain what is expected to access and successfully complete the online assessment to avoid frustration and misguided student efforts. To summarize, instructors will be most effective when they:

1. Repeatedly and consistently explain the importance of professional skills (including reflection) in the context of their project (and team) success and their professional and personal lives. Giving examples of feedback from alumni is effective for making statements credible.
2. Utilize module pre-class and in-class assignments (see resources provided on IDEALS website) to prepare students with context, examples, and understanding that will enable them to be successful in assessments. Follow the instructor's guide to use them effectively.
3. Set up IDEALS assessment assignments online (on IDEALS website) and demonstrate to students how they will access and complete assignments online. Give them examples of good and weak submittals and ask them to score the work using the rubric you will use to score their responses (examples and rubrics are available to you as IDEALS downloads). Set high expectations for their submittals. Explain that students will find your feedback online within a given time period. Explain also that they will be able to access their submittals and your feedback at the same location at later times for future use.
4. Provide prompt and specific feedback that offers encouragement and suggestions for improvement.

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