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Using an Engineering Design Problem to Assess Attainment of Life-Long Learning*

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Embedded indicators provide a direct measure of student performance against a defined curricular standard based on actual course work. When combined with other, more traditional measures of student outcomes, embedded indicators provide opportunities for validation and triangulation of assessment evidence. USMA uses established rubrics and cadet performance on embedded indicators in the curriculum to assess accomplishment of each of its ten program goals. One of these goals—continued intellectual development—reflects life-long learning, which is valued at many colleges throughout the country. This goal, however, is difficult to measure. We have overcome this difficulty through the implementation of a goal-centered general education curriculum based on established, collaboratively generated, goal standards. We identify course products, embedded in the curriculum, that are aligned with the standards and then develop instrument-specific rubrics that align the course product with the goal standard. We have used this assessment methodology to inform USMA faculty about the extent to which our students achieve the academic program goals that we have established.

Keywords: life-long learning; engineering design process; assessment; embedded indicators

INTRODUCTION

THE 2002 REPORT of the Greater Expectations National Panel, formed by the Association of American Colleges and Universities, calls for a dramatic reorganization of undergraduate education in the United States and recommends a broad, liberal education to prepare students to face world issues [1]. This philosophy is not new in engineering education. William Burr, at a meeting of the Society for the Promotion of Engineering Education in 1893, observed that: 'The first and fundamental requisite in the ideal education of young engineers, a broad, liberal education in philosophy and the arts, is a precedent to the purely professional training' [2]. Many engineering programs have embraced the idea that the essential preparation for an engineer includes a balanced study of the natural sciences, social sciences, and humanities [3]. In recent years, the educational focus has turned away from the curriculum and towards students and their learning [4, 5].

During the 1980s, the increased pressure on educational institutions to be accountable to their constituents led to widespread curricular reform [6]. Prados traces the history of the changes that led the Accreditation Board of Engineering and Technology, Inc. (ABET) to the 1996 adoption of Engineering Criteria 2000 (EC2000). EC2000 emphasizes learning outcomes, assessment and continuous improvement, rather than detailed curricular specifications [7, 8]. The eleven learning outcomes (outcomes 3a through 3k) that comprise the EC2000 Criterion 3 (Program Outcomes and Assessment) represent a set of broad technical and professional skills that are desired in all undergraduate engineering graduates [9]. A significant challenge for engineering programs is the requirement to demonstrate that graduates are achieving these eleven desired outcomes. Assessing student attainment of the so-called professional skills, including outcome 3i, a recognition of the need for, and an ability to engage in life-long learning, can be particularly challenging. Three hurdles have impeded the development of viable tools to assess engineering students' attainment of the professional outcomes: a consensus about definitions, the scope by which the outcome is assessed, and the nature of the outcome itself [2].

Candy defines the principal aims of life-long learning as '. . . equipping people with skills and competencies required to continue their own 'self education' beyond the end of formal schooling' [10]. To establish evidence that graduates are meeting ABET outcome 3i, Marra's assessment plan includes the development and validation of an instrument that measures aspects of the curricula that support life-long learning. Data suggests that work on research projects can encourage students to pursue life-long learning activities [11]. Litzinger recounts the work of Candy, Garrison and Flammer in summarizing the personal attributes (to include creativity, self-discipline, self-awareness and persistence) and skills (to include highly developed information seeking and retrieval skills) of the life-long learner [12].

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This paper focuses on a nuclear engineering program assessment tool that infers individual cadet accomplishment of an academic program goal from design team work. We assess if student design team members demonstrate a capacity for life-long learning, by displaying the attributes and skills of a life-long learner, through completion of portions of an engineering design project.

As the sole institution of higher learning in the nation whose primary responsibility is to educate cadets for career service as professional Army officers, the United States Military Academy at West Point (USMA) offers an undergraduate academic curriculum with extensive common general education requirements and a study in-depth component. The overarching goal of the academic program for USMA is for graduates to be able to anticipate and respond effectively to the uncertainties of a changing technological, social, political and economic world. Since it is not possible to anticipate all the demands graduates will face, and since it is not possible for the Army to school or train its officers to handle every conceivable challenge, graduates must be motivated and equipped to learn on their own and be willing and able to obtain new ideas, methods and technologies. Such capabilities can result from the breadth of the core academic program, from specialization in one or more disciplines, and from the inspiration and confidence stimulated by, for example, a capstone design project [13]. At USMA life-long learning is called continued intellectual development (CID) and is one of the academy's academic goals. The CID goal, that graduates should demonstrate the capability and desire to pursue progressive and continued intellectual development, supports the overarching goal.

ASSESSING THE CID GOAL

An important component of creating a coherent and purposeful academic program is assessment. Assessment is a tool used to improve learning, teaching and the curriculum, and it is a necessary and integral part of improving student achievement. Assessment of the academic curriculum allows West Point to maintain the currency and the relevance of the academic program to Army needs. Through a systematic assessment program, USMA can anticipate and respond to changes in the Army and in higher education. Additionally, such an assessment process allows evaluation of cadet attainment of an academic program goal, yielding program improvements to enhance cadet learning and development. To assess student achievement of institutional academic goals, the Dean of the Academic Board formed an Assessment Steering Committee. The Assessment Steering Committee established the standards that delineate goal achievement for each academic goal and also identified a set of course products, such as a design project that is already in the curriculum, referred to as an embedded indicator, by which students may demonstrate goal achievement.

Cadets who do not major in an engineering discipline must, as part of their general education requirements, complete a three-course engineering sequence so that they develop sound methods for analyzing and dealing with scientific and technical matters [14] or 'desirable habits of mind' [15]. Nuclear engineering, taught by the Department of Physics, is one of seven three-course engineering sequences offered. An engineering design project from a nuclear engineering sequence course was selected by the Assessment Steering Committee as an embedded indicator for assessing cadet achievement of the CID goal.

A CID goal team, formed by the Assessment Steering Committee and consisting of senior faculty from several distinct disciplines, articulated two statements of what graduates who achieve this goal can do. The first statement is that graduates can apply diverse strategies and methods to grasp issues and solve problems, called the self-learning domain of the CID goal. The second statement is that graduates seek advanced study in areas of professional and personal interest and pursue subjects in depth, called the pursue-learning domain of the CID goal. These two statements form the basis for assessing if cadets are achieving performance outcomes that demonstrate satisfactory completion of the goal.

An objective of the goal team was to assess accomplishment of the CID goal through cadet team completion of an engineering design project. The focus of the rest of this paper is on the assessment conducted by the nuclear engineering program in the Department of Physics for the self-learning domain of the CID goal.

The goal team provided the nuclear engineering program director with the goal standards and a scoring guide (rubric) that described the criteria for student performance [16] in the self-learning domain. The goal team determined that cadets achieve the self-learning domain by assessing ideas and problems and forming opinions using critical and creative thinking skills. They assess ideas and problems by defining the problem, by recognizing unstated assumptions, by recognizing the need for pertinent information, by finding and evaluating pertinent information, by recognizing and addressing their shortcomings in comprehending a subject, and by assessing the effectiveness of a problem solution. Cadets form opinions by formulating relevant, diverse, and promising hypotheses, by evaluating these hypotheses and drawing valid conclusions, and by using the conclusions as the basis for a solution and future exploration of related issues.

The engineering design projects are typically accomplished in the final year of the academic curriculum; consequently, much of the foundation for cadet self-learning as a result of the core curriculum experience has been set. An engineering

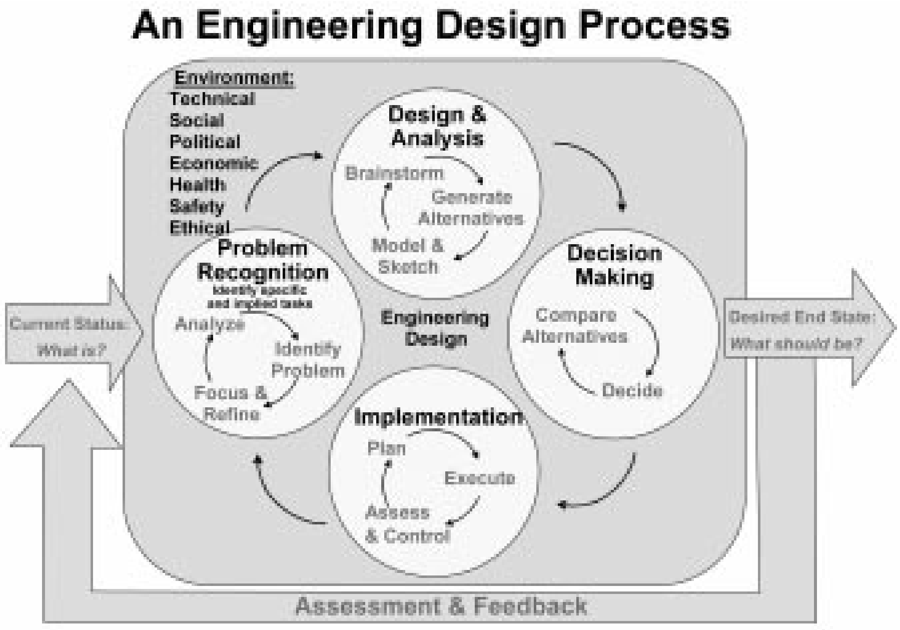

Fig. 1. An Engineering Design Process (EDP) used in the USMA nuclear engineering program.

design process used at USMA, as illustrated in Fig. 1, is a methodology that consists of four major phases; problem definition, design and analysis, decision-making, and implementation. All four phases are interconnected and are performed within a problem-solving environment constrained by technical, social, political, economic, health, safety and ethical considerations and draw on the broad curriculum of the core academic experience. Each of the four major phases is itself a cycle—a characteristic that underscores the need for continuous assessment and formulation of opinions throughout the engineering design process. Portions of the engineering design process align with elements of the rubrics developed for the self-learning domain of the CID goal.

The leadership of the nuclear engineering program received the goal standards and the rubric and then aligned the requirements of the engineering design project to the goal standards. The performance of cadet design teams on those portions of the design project requirements that align with the goal are extracted and plotted using an interval scale. The grade distribution of the two-person cadet design teams are then used to infer individual cadet accomplishment of the goal, and to determine if changes are needed to the program or the design project. This methodology, as illustrated in this paper, has proven to be a useful assessment tool.

ENGINEERING DESIGN PROCESS IN THE NUCLEAR ENGINEERING PROGRAM

The leadership in the NE program noted a strong correlation between an existing system of in-progress reviews (IPRs) used for implementing the engineering design process (EDP) and the self-learning domain portion of the rubric; however, the IPR system defined most of the requirements in terms of meeting or exceeding standards. Consequently, the leadership extended the self-learning domain rubric from the goal team by developing expectations for cadets to meet standards (MS) or exceed standards (ES) in an effort to better align the rubric with the existing IPR system. The ES and MS achievement levels were developed in a series of faculty meetings. The faculty reviewed the performance of cadets on previous projects, reached agreement on the minimum performance standards each cadet was expected to meet, and articulated the criteria for achieving excellence by exceeding standards.

The adjusted CID goal standard rubric is shown in Table 1. Within the self-learning domain there are five standards (CID 1 through CID 5) with MS and ES criteria defined. The faculty used these standards within the nuclear engineering design project to assess accomplishment of the self-learning domain of the CID goal.

Litzinger recommends that in experiences that demand self-directed learning, the reactions and success of students must be carefully monitored, and they must receive regular, formative feedback [17]. To that end, successful completion of the project is facilitated through in-progress reviews. They incorporate a formative assessment tool to flag problem areas in the students' work and are oral briefings or written requirements that provide an opportunity for cadets to back-brief the instructor on their progress in completing the design project. Through the IPR both the student and the instructor gain useful information. The student gets advice from the instructor on issues of concern, and is then able to identify and attend

Table 1. CID goal standard rubric (extract) for the self-learning domain

Element	Meets Standard (MS)	Exceeds Standard (ES)
Assess ideas and problems	**CID 1**. Cadets define the problem to be solved by identifying specified tasks, assumptions, implied tasks, constraints, limitations and restrictions.	**CID 1**. Cadets define the problem to be solved, and show evidence of defining possible branches and sequels, by recognizing specified tasks, assumptions, implied tasks, constraints, limitations and restrictions demonstrating creativity and higher-order thinking.
	CID 2. Cadets determine what information is required to solve a problem; acquire that information from appropriate sources; and, when available information is imperfect or incomplete, formulate reasonable assumptions that facilitate problem solution.	**CID 2**. Cadets determine what information is required to solve a problem; acquire that information from appropriate sources; and, when available information is imperfect or incomplete, formulate reasonable assumptions that facilitate problem solution demonstrating creativity, ingenuity and higher-order thinking.
	CID 3. Cadets assess the effectiveness of a solution to the problem, to include economic, social and political implications of the solution.	**CID 3**. Cadets assess the effectiveness of a solution to the problem, to include economic, social and political implications of the solution and on possible branches and sequels to the solution.
Form opinions	**CID 4**. Cadets formulate a reasonable alternative solution to a problem demonstrating creativity in the formulation of this alternative.	**CID 4**. Cadets formulate multiple alternative solutions to a problem demonstrating creativity in the formulation of these alternatives.
	CID 5. Cadets demonstrate insight in their communication of ways to apply the solution.	**CID 5**. Cadets demonstrate insight in broadening the application of the solution to other scenarios and situations.

to areas that may require more thought or more study. Knowledge gained is available to students in strengthening subsequent project requirements. The instructor learns about student understanding of the project at multiple time points before the final design is due and so can modify the project or encourage students to address deficiencies.

The IPRs are aligned with the phases of the EDP, as shown in Fig. 2, and provide the cadets and their instructor with a logical means to break the design process into manageable steps. IPR 1 focuses on phase 1 of the EDP, problem recognition. The goal of this phase is for the cadets to clarify the objectives set out by the client and to

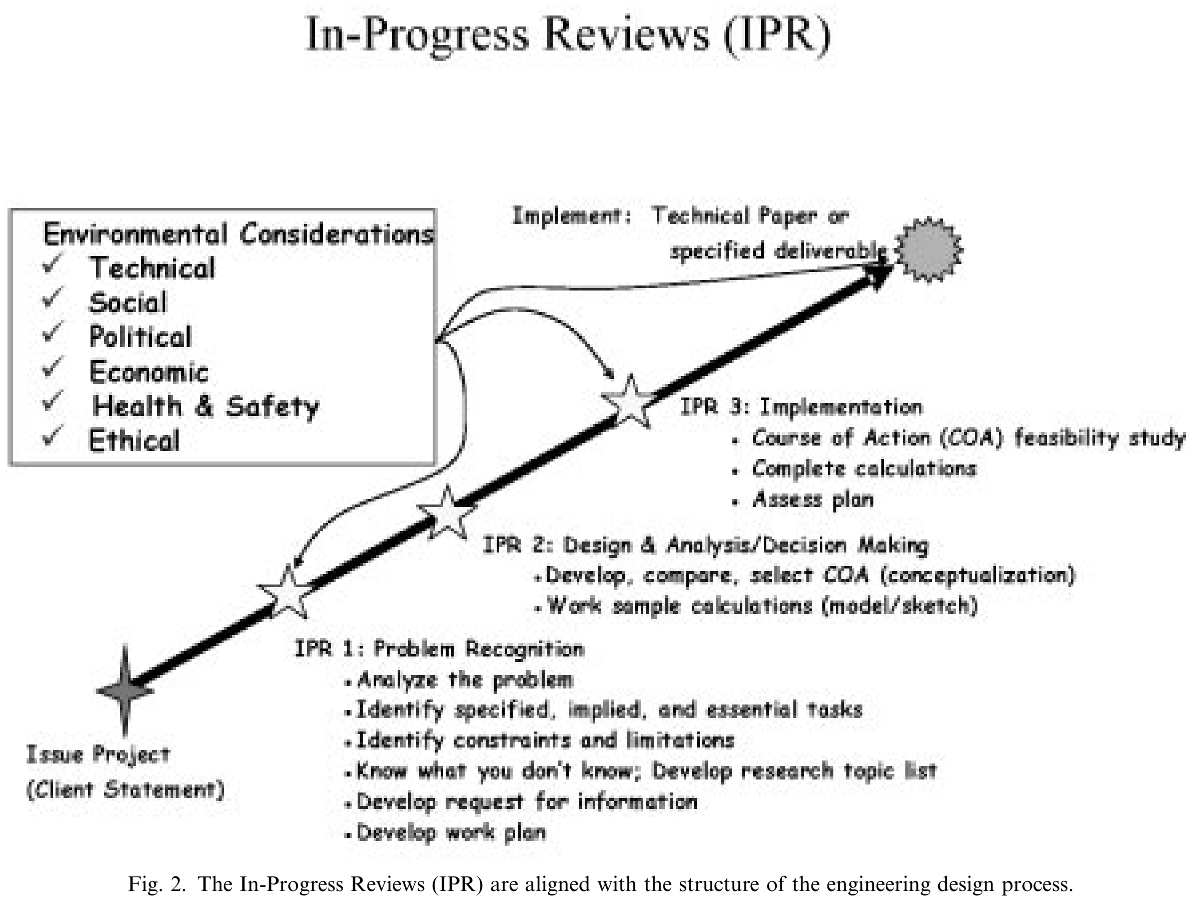

Fig. 2. The In-Progress Reviews (IPR) are aligned with the structure of the engineering design process.

gather information needed to develop an engineering statement of what the client wants. Cadets often need to learn on their own to gain better insights into framing the problem. IPR 2 focuses on phase 2, design and analysis, and on phase 3 decision making. The goals of these phases are the conceptualization and the comparison of acceptable, suitable, distinguishable and complete courses of action, and the completion of sample calculations and sketches. IPR 3 focuses on phase 4, implementation. The goal of IPR 3 is to assess the feasibility of the recommended course of action, to complete the required calculations, and to produce a detailed design. The final phase of the EDP is the submission of the design deliverable and its assessment for accomplishing the client's desires.

A Nuclear Engineering Design Supplement, produced by the Physics Department and issued to each cadet, provides the grading standards and an outline of items for inclusion in each IPR submission.

ASSESSMENT METHODOLOGY

The assessment methodology is based on a five-step process [18]. First, the NE program director and the course director align the IPR requirements with the CID goal standard. Criteria for meeting and exceeding the standards are established so that the instructors grading the IPR requirements know the standards. Second, the performance of cadet design teams on the requirements are extracted and plotted using an interval scale. On the interval scale, a five is outstanding and corresponds to a grade of A+, A, or A–. Four is excellent and represents a B+, B, or B–; three is satisfactory and represents a C+, or C; two is marginal and represents a C– or D; and one is unsatisfactory and represents an F. Third, the distribution of cadet team grades is used to assess if the cadet design teams have demonstrated a capacity to achieve the CID goal. The system of IPRs allow for multiple assessments, since many of the requirements of the goal are assessed at multiple times. Fourth, the course director and program director review the graded outcomes. For example, it is considered suspicious if the most frequent grade is an A or B with no D or F. This rating, a possible indicator of grade inflation, begins a dialogue among the entire NE program faculty about grading standards. The program leadership also reviews the grading methodology, the instrument itself, the rubric standards, and environmental factors etc. to determine if programmatic changes are needed. Fifth, changes are made to the program, the design project, grading paradigms etc. as appropriate.

RESULTS

The criteria for meeting standards and exceeding standards for each IPR and the final design are defined in the Nuclear Engineering Design Supplement. For example, IPR 1 points are allocated with problem recognition requirements accounting for 70% of the total points, management tools (Gantt chart, project journal etc.) accounting for 20% of the points, and format and grammar accounting for the remaining 10% of the points. A partial example of the IPR 1 grading guidelines for the problem recognition portion is shown in Table 2. For each requirement (REQ) that contains MS and ES criteria, 80% of the points are allocated for MS and 20% of the points are allocated for ES. For example, in Table 2 requirement 1.3 (the third requirement of IPR 1 is identification of implied tasks) is worth a total of 75 points; the MS criteria outlined as requirement 1.3M is worth 60 points (80%) and the ES criteria outlined as requirement 1.3E is worth 15 points (20%). This allocation of points was selected since 80% represents a letter grade of B (76.5% to 86.9%), excellent performance in the NE program. By obtaining some portion of the remaining 20% of the points allocated toward the ES criteria, cadets can achieve the letter grade of A ($>87\%$) for that requirement. For requirements with only MS standards, 100% of the points are allocated to MS criteria.

Table 2 also indicates the relative weight placed on some of the criteria. For example, requirement 1.3 is more heavily weighted (75 points) than the other criteria since identifying implied tasks requires cadets to rely on their reasoning and creative thinking skills. Requirements where cadets must demonstrate ingenuity, reasoning and creative thinking skills, as well as a need to think 'out of the box' are more heavily weighted.

Since the distribution of grades is used as a means to make an assessment, all instructors use the same three-part grading paradigm. First, cadets must demonstrate appropriate knowledge, principles, engineering concepts etc. If not combined with additional earned points from higher-order skill activities (ES), cadets' sole demonstration of fundamental knowledge (MS) equates to D-level (60% to 65.9%) work. Secondly, the cadets must present their ideas in a coherent, logical plan and demonstrate their relevance. Cadets accomplishing this can receive up to an additional 10% to 20% of the allocated points for the requirement. This will essentially bring the cadets up to C-level (66% to a 76.4%) work. Finally, the cadets must use correct values for any data, regulatory limits etc. Cadets can then receive up to an additional 10% to 20% of the allocated points for the requirement; consequently, achieving B-level work (A/B-level work if there is no ES opportunity for the requirement). For example, requirement 1.3M is worth 60 points. The instructor allocates 40 points for cadets to identify sufficient implied tasks that cover political, social, economic, technical, health, safety, and ethical considerations. The instructor allocates 10 points for cadets articulating the appropriate relevance of each of the implied tasks. Another 10 points is

Table 2. IPR 1 grading guidelines and results (only Requirements 1.1 through 1.6 are shown)

REQ	Problem recognition	CID	MS	ES	Average for all 14 groups	Group 1
1.1M	**Revised Problem Statement (MS)**: Identifies the need to be solved by engineering solution given by client.	**1**	40		40	40
1.1E	**Revised Problem Statement (ES)**: Anticipates and identifies needs to be solved by engineering solution beyond that given by the client.	**1**		10	5.0	7
1.2M	**Specified Tasks**: Identifies specified tasks given by the client	**1**	25		22	20
1.3M	**Implied Tasks (MS)**: Discerns and articulates relevant political, social, economic, technical, health and safety, and ethical tasks that are not specified.	**1**	60		54	40
1.3E	**Implied Tasks (ES)**: Discerns and articulates relevant political, social, economic, technical, health and safety, and ethical tasks that are not specified and demonstrates creativity, ingenuity, and higher-level thinking. Anticipates calculation and engineering requirements beyond those required for the engineering solution.	**1**		15	5	4
1.4M	**Essential Tasks**: Discerns and articulates relevant specified and implied tasks that are essential to the engineering requirement.	**1**	25		22	25
1.5M	**Restriction, Limitations, Constraints (MS)**: Discerns and articulates relevant political, social, economic, technical, health and safety, and ethical restriction, limitations, and constraints.	**1**	40		38	40
1.5E	**Restriction, Limitations, Constraints (ES)**: Discerns and articulates relevant political, social, economic, technical, health and safety, and ethical restriction, limitations, and constraints demonstrating creativity and higher-level thinking.	**1**		10	3.0	0
1.6M	**Determine Previous Work in the Field (MS)**: Conducts literary research reference the problem statement. Discusses the results of the literary research (not a cookbook list of journals, articles etc.). Sources are listed in a bibliography or works cited page.	**2**	20		17	15
1.6E	**Determine Previous Work in the Field (ES)**: Literary research is extensive and considers social, political, economic, technical, health & safety, and ethical branches of research. Research extends to possible branches and sequels to the engineering solution.	**2**		5	3.0	2.5

allocated for cadets being correct and complete, i.e., an implied task must have correct values, specifications, or regulatory limits etc. The instructor allocates additional points for meeting the ES criteria (not shown).

The NE program leadership aligns the goal rubric standards with the existing design requirements for each of the IPRs and the final design deliverable. An example of this alignment is shown in Table 2 for some of the requirements of IPR 1. There is a strong correlation of the standards of CID 1 with requirements 1.1 through 1.5. Requirement 1.6 aligns very well with the standard for CID 2. The requirements of IPR 1 (problem recognition) have a strong correlation with the standards of CID 1 and CID 2. This stands to reason since the problem recognition phase of the EDP is concerned with assessing the problem and

Table 3. CID MS standards 1 through 5 aligned with the IPRs and Final Design

	IPR 1	IPR 2	IPR 3	Final design
CID 1. Cadets define the problem to be solved by identifying specified tasks, implied tasks, constraints, limitations and restrictions.	✓	✓	✓	
CID 2. Cadets determine what information is required to solve a problem; acquire that information from appropriate sources; and, when available information is imperfect or incomplete, formulate reasonable assumptions that facilitate problem solution.	✓	✓	✓	
CID 3. Cadets assess the effectiveness of a solution to the problem, to include economic, social, and political implications of the solution.		✓	✓	✓
CID 4. Cadets formulate a reasonable alternative solution to a problem demonstrating creativity in the formulation of this alternative.				
CID 5. Cadets demonstrate insight in their communication of ways to apply the solution.		✓	✓	✓

Table 4. Grade distributions of the CID rubric for each IPR and the Final Design

	IPR1		IPR2	IPR3				FINAL Design	
Likert Rating	CID 1	CID 2	CID 2	CID 1	CID 2	CID 3	CID 4	CID 3	CID 5
% Outstanding (5)	56%	54%	86%	43%	93%	57%	67%	50%	71%
% Excellent (4)	21%	20%	14%	57%	7%	14%	27%	26%	7%
% Satisfactory (3)	10%	5%	0%	0%	0%	7%	0%	12%	7%
% Marginal (2)	6%	5%	0%	0%	0%	0%	0%	0%	0%
% Unsatisfactory (1)	7%	16%	0%	0%	0%	21%	7%	12%	14%

demands innovative thinking, self awareness, and a need for discovery to frame the problem correctly for the client. These traits include the 'measurable attributes' [19] that may be evidence of students who have attained the life-long learning outcome.

However, IPR 1 is not the only opportunity to assess CID 1 and CID 2 standards. Table 3 shows the alignment of all of the CID standards across all of the IPRs and the final design deliverable. As suggested by Table 3, there is an opportunity for multiple measures of each outcome (assessment triangulation) [20] by looking at design group performance on CID 1, CID 2 and CID 3 requirements across multiple IPRs and the final design.

Table 2 lists the achieved grades, using the grading paradigm previously discussed, for one (randomly selected) of fourteen cadet design groups and the average grades for all fourteen groups. Each design group consists of two cadets. As evidenced by Table 2, it is possible for some design groups to receive partial MS and partial ES points. For example, group 1 in requirement 1.3M earned 40 of 60 available points. This could occur if, for example, group 1 did not adequately identify all implied tasks, could not adequately discuss the relevance of these implied tasks, used incorrect values or conditions, or did not completely and correctly address all problem requirements. By demonstrating ingenuity and creative thinking in some aspect of the requirement as described by the ES criteria, Group 1 earned 4 of the available 15 ES points on requirement 1.3E.

The specific grade distributions of the requirements that align with the CID rubric are converted to an interval scale. Table 4 lists the percentage of interval scale results based on the grade distributions for all the IPRs and the final design deliverable for those grading requirements aligned with

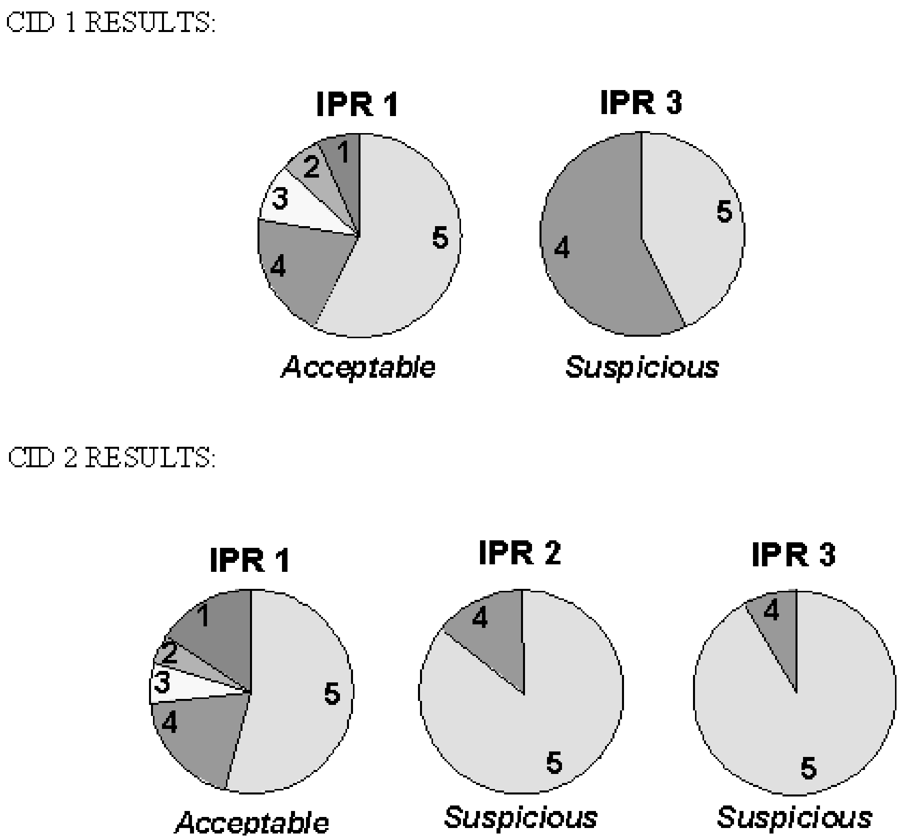

Fig. 3. CID 1 results applied against the interval scale and the assessment criteria for IPR 1 and IPR 3, and CID 2 results for IPR 1, IPR 2, and IPR 3.

specific CID 1 through CID 5 standards. For example, Table 4 shows that for IPR 1, 56% of all cadet design team submissions for requirements aligned with CID 1 were evaluated based on the previously discussed grading paradigm to be outstanding (A+, A, A–), while 5% of all submissions for requirements aligned with CID 2 were evaluated as satisfactory (C+, C).

The interval scale distributions, displayed in pie charts in Fig. 3 based on the data in Table 4, become the basis to analyze cadet accomplishment of the CID goal. The numbers in the pieces of the pie represent the interval scale values. The nuclear engineering program faculty analyzes the interval scale pie charts representing the graded outcomes and, using the criteria given in Table 5, assess if the cadets attained the self-learning domain.

For example, as shown in Table 4 for CID 1 of IPR 1, 56% of the grades were A+, A or A– which is a 5 on the interval scale (Outstanding), 21% were 4 (Excellent), 10% were 3 (Satisfactory), 6% were 2 (Marginal), and 7% were 1 (Unsatisfactory). Using the grade distribution rubric of Table 5, the faculty assessed that these results were acceptable (most frequent grades are C or better with less than 20% C–, D or F). For CID 1 of IPR 3, the results are suspicious. Between the two reviews, the cadets showed an improvement in their ability to define a problem to be solved through identification of specified tasks, implied tasks, constraints, limitations and restrictions. Although the results of IPR 3 were assessed as suspicious the faculty determined that there were no issues with the grading paradigm, the requirements, the assessment methodology, or evidence of grade inflation. The cadets appeared to take advantage of the formative assessment opportunity of IPR 1 and were able to synthesize and apply this knowledge to IPR 3. The overall faculty assessment was that the cadets were exceeding standards (ES) for CID 1.

The CID 2 results, as displayed in Fig. 3, show that the distribution of grades for IPR 1 was acceptable while IPR 2 and IPR 3 results were suspicious. Based on the grade distribution change from IPR 1 through IPR 3, the cadets improved their ability to determine what information was required to solve a problem; acquire that information from appropriate sources; and, when available information was imperfect or incomplete, formulate reasonable assumptions that facilitate problem solution. The percentage of unacceptable grades in IPR 1 was 16%. This was a concern until the results of IPR 2 and IPR 3 were available. The faculty determined that the cadets took advantage of the formative assessment opportunity of IPR 1 and applied that knowledge to the requirements of IPR 2 and IPR 3. The overall faculty assessment was that the cadets were meeting standards (MS) for CID 2.

Table 5. Criteria to assess grade distributions

Level	Description
Suspicious	Most frequent grade is an A or B with no D or F
Acceptable	Most frequent grades are C or better with less than 20% C–, D, or F
Marginal	Most frequent grades are C r better with at least 20% C–, D, or F but no more than 40% C–, D, or F
Unacceptable	Most frequent grades are C–, D, or F

The Table 4 data associated with CID 3 in IPR 3 and the final design were similarly displayed and demonstrated an improvement in the ability of cadets to assess the effectiveness of a solution to the problem, to include economic, social and political implications of the solution. The faculty was concerned that 21% of the CID 3 results from IPR 3 received grades of unacceptable, but this reduced to 12% by the final design. Anecdotally the faculty believed cadets had the most difficulty with this requirement, and the assessment supported this belief. The overall faculty assessment was that the cadets were meeting standards for CID 3; but based on these results, the nuclear engineering program is including in the design supplement additional techniques for assessing the effectiveness of a design solution. The assessment results for CID 4 and CID 5 were similarly completed and resulted in a faculty judgement that cadets met standards for CID 4 and CID 5 requirements.

DISCUSSION AND CONCLUSIONS

Through this methodology, we assess cadet attainment of a difficult to measure academic institutional goal, the continued intellectual development goal. We use the distribution of cadet grades on design team project requirements to assess individual cadet attainment of the CID goal, and to assess the nuclear program. This methodology, allowing an assessment of goal requirements over multiple IPRs and the final design project, gives the program leadership critical information about cadet attainment of program goals and the CID goal.

The methodology results for CID 1 through CID 5 led the NE faculty to assess that the cadets in this course had attained the self-learning domain of the CID goal. Additionally, the approach demonstrated that the goal rubrics could be easily used by any academic department.

The process confirmed prior faculty suspicions about the ability of the cadets to judge the effectiveness of a problem solution considering a variety of economic, social and political implications (CID 3). As a result of this feedback, the NE program instituted changes to improve the development of cadets in this area while sustaining the success in cadet performance on CID 1, CID 2, CID 4 and CID 5 standards.

We believe that this assessment methodology has wide application to a variety of academic programs. Use of the design project and the system of IPRs as an embedded indicator proved to be a useful tool that facilitated program assessment, provided feedback about the progress of each group in the design problem, and generated useful assessment data. The data allow the program director and course director to identify trends, to make adjustments to the course, and can even help to identify how well an engineering program meets ABET accreditation goals.

The CID rubrics and IPR system will be applied to all of the design projects in the NE program allowing us to gather data on cadet performance over several semesters. This will provide a longitudinal assessment opportunity and improve the data that drives changes in the program.

Assessing the grade distribution for the embedded indicators must be tempered with discussion of why the results were obtained. Such factors as rigor, outside influences on cadet time, program design etc., must be considered before making the final assessment of the attainment of each goal. The program leadership conducts formal assessment reviews with the entire faculty to consider the methodology, the embedded indicators, and other pertinent factors before making a final assessment of cadet goal attainment. Such assessment feedback drives changes to the program to improve student performance and educational outcomes.

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