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Designing Courses using Case Studies and Content, Assessment, and Pedagogy (CAP) to Cultivate Professional Skills among Engineering Students*

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Informed from (1) case-based pedagogy literature, (2) content, assessment, and pedagogy (CAP) aspects of developing courses, and (3) two professional development workshops in which engineering faculty created case-based materials to incorporate professional skills into traditional engineering curricula, this paper guides engineering faculty in their creation of short courses or workshops that engage their students in professional skills that often are not taught within traditional engineering classrooms. Steps, excerpts, and examples that are useful in the development of these courses or workshops are provided throughout the paper. The authors envision that the paper will serve as a user-friendly resource that engineering faculty can use to identify, develop, and implement courses that seek to address professional skills in their academic settings.

Keywords: professional skills; case-study; engineering undergraduate; course development

1. Introduction

Literature and national reports have highlighted the importance of professional skills (e.g., leadership, communication, interpersonal, working in multidisciplinary teams) for engineering undergraduates [1–7]. For example, Passow [6] surveyed 4,225 recent graduates from 11 engineering majors and identified teamwork, communication, data analysis, and problem solving skills to be the most important skills for professional work after graduation. Furthermore, studies by McMaster and Lang [8], McMaster and Matsch [9], and Wisler [10] showed engineering employers desire students who possess both technical and professional skills.

Given the importance of professional skills, there have been calls to nurture these skills within students during their undergraduate years by purposefully teaching these skills [7, 11, 12]. One of the ways for institutions to train undergraduates on professional skills is by "setting students' technical work in the context of decision-making situations" [6, p. 112]. Decision-making situations such as those encountered in professional life can be re-created through a case study.

A case study, usually written in narrative form, is a record of a real life situation/issue which includes contextual facts, opinions, and prejudices that contribute to the decisions made by involved people [13]. In the engineering education setting, case studies can help convey the complexity and ambiguity of the practical world. The case is presented to students for analysis and discussion so that appropriate problem-solving actions can be determined [13].

There are advantages for using a case study in curriculum. These include students' development of positive attitudes towards learning [14, 15], the addition of realism to courses, and the application and/or relevance of engineering to the real world [16]. Due to these advantages, case-based pedagogy has been used to teach professional skills to students [17–18]. For example, as Garg and Varma [18] identified, using a case study approach helps improve software engineering students' professional skills such as communication and critical thinking and better prepares students for industry careers.

Despite the advantages, the use of case studies in engineering undergraduate curriculum has been

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limited. One major barrier has been engineering faculty's inexperience in combining case studies with professional skills in courses or syllabi [11, 17]. The importance of carefully developing and implementing case studies into a course is highlighted by Yadav, Shaver, and Meckl [19], who claim that if cases are not properly implemented, conceptual understanding of course concepts will not be translated to students and the benefits of using cases will not be obtained.

Citing Blumenfeld, Puro and Mergendoller [20], Yadav et al., recommend designing a case that both "bring(s) the lesson to students" and "bring(s) students to the lesson" [19, p. 61]. Although well-written cases commonly bring the lesson to students, bringing students to the lesson requires teaching pedagogies that cognitively engage students on the main concept of the lesson and allows students to apply the concepts to new situations [19]. Therefore, opportunities must be given to students through appropriate tasks and assignments that apply the concepts learned. It is not enough for cases to be interesting; they should illustrate abstract course concepts and should become the focal point around which course concepts are structured [19].

Many studies have used engineering cases to train undergraduates for various professional skills [19, 21–23]. These cases, however neither provide the steps to designing, developing, and implementing cases through the duration of the engineering course, end nor do they include ways to assess students' learning via these case studies. Therefore, this paper attempts to add value to the existing literature by outlining the steps to developing, implementing, and assessing case-based pedagogy within engineering courses. This paper is written based on (1) the information presented and insights gained from two workshops helping US and international engineering faculty develop a curriculum that would teach professional skills to undergraduates using case-studies, (2) the knowledge from content, assessment and pedagogy (CAP) aspects of developing materials, and (3) the literature and experiences from various experts in using case-based pedagogy in undergraduate curricula.

This paper is organized into two sections. The first section provides information about the two workshops conducted by the authors. It highlights challenges faced by faculty to integrate professional skills training into a course curriculum as well as desired course features that faculty would like to see in curricula with this focus. The second section provides ways to address the challenges and to integrate these desired features by applying the CAP model, which will help faculty members develop course materials that nurture professional skills. Specifically, the second section is divided into three parts. The first part discusses the situational factors associated with the course development and identifies the purpose of potential course materials. The second part relates to the CAP aspects of planning a course. This discussion involves identifying and developing learning goals, using multiple assessments to measure students' understanding, applying effective teaching methods, and ensuring that the three aspects are aligned. The third part focuses on the implementation phase of the course, where information on synthesizing all sections and developing a structure for the planned course will be discussed.

2. Faculty workshops

Two workshops that guided faculty and administrators on ways to integrate professional skills training in an engineering undergraduate course occurred at a large U.S. Midwestern University in summer 2012. The workshops offered participants opportunities to discuss issues related to teaching professional skills in undergraduate classrooms, to develop a teaching curriculum that would develop students' professional skills, and to share ideas in assessing students' progress on the teaching of professional skills in engineering classrooms. The workshops were developed and organized jointly by the university's Director of Engineering Leadership Minor, the Director of the Office of Professional Practice, and the Assistant Director of Global Professional Practice Programs.

Nine engineering faculty members from Aeronautics and Astronautics, Biomedical Engineering, Civil Engineering, Engineering Education, and Mechanical Engineering attended the first workshop. There were also six directors of various organizations whose focus include experiential learning programs as well as programming for underrepresented student populations. Eleven science and engineering faculty members from the Middle East participated in the second workshop. Their disciplines included Mechanical Engineering, Chemical Engineering, Electrical Engineering, and Chemistry.

In the workshops, participants were divided into groups of four or five. The organizers mixed participants by their disciplines so that no more than two participants from the same discipline would be in the same group and so that diverse points of view could be shared in small group discussions. During the workshop, groups were asked to discuss and to develop ideas and to present solutions. Each group assigned a participant to capture and to transcribe main points of the discussions and their generated ideas.

All participants agreed that engineering undergraduates must possess professional skills. They also indicated that they shared responsibility to foster the development of professional skills, and many have even tried to teach professional skills to students in their courses. However, many participants were unsure how to effectively teach/train professional skills to students in their undergraduate classroom settings. When participants were asked to describe the main challenges when incorporating professional skills training in a classroom environment, two major themes appeared: (1) content challenges and (2) implementation challenges. Highlighted challenges spoke to the fact that, in general, engineering faculty and program directors felt unequipped to address professional skills concerns, especially as they had never received formal training themselves. Specifically, content challenges relate to the addition or modification of course materials, learning objectives, and syllabi while implementation challenges relate to the day-to-day running and management of the course and delivery of the pre-determined content. Table 1 and 2 list the identified challenges.

During the workshops, participants were also asked what features they would like to include in a curriculum when training students in professional skills (see Table 3).

The workshops helped identify some of the main challenges for faculty to integrate professional skills training within a classroom environment. Furthermore, it highlighted some of the features that faculty would like to include in their curriculum, but are unclear how to implement successfully without compromising students' interest/gains.

3. Integrating professional skills training in an undergraduate curriculum

To help faculty address the challenges and integrate the desired features, the authors provide a step-by-step guide to create a curriculum that would nurture students' professional skills in a traditional classroom environment. Following this systematic process will enable engineering faculty in the U.S. and around the world to develop quality training courses that teach important professional skills

Table 1. Course content challenges when incorporating professional skills training in a classroom environment

1. Mapping and linking different professional skills training (e.g., different leadership components) for students so they gain a holistic perspective of the multifaceted nature of professional skills.
2. Developing and integrating additional materials/content to an existing course to aids in the professional development of students (e.g., acquisition of leadership skills).
3. Deciding what is included when structuring the course syllabi.
4. A lack of materials, training, or guides for professors who are redesigning an existing course and desire to integrate professional skills components in their course.
5. Maintaining a balance between technical and non-technical content in courses with demanding course requirements and time constraints.

Table 2. Classroom implementation challenges when incorporating professional skills training in a classroom environment

1. Leveraging and accounting for unique student experiences when discussing targeted professional skills. For example, maintaining relevance and making connections so that students with different professional, national, and cultural backgrounds can have a unifying experience in a classroom setting.
2. Engaging engineering students when teaching professional skills at all levels of undergraduate education. In the first years of an undergraduate program students may be focused on getting a good grade while in final years may be more focused on completing coursework for graduation and job applications.
3. A lack of strategies to encourage the active development and practice of professional skills. For example, how to have a young/inexperienced student assume a leadership role in a classroom environment? or how to manage and facilitate effective student teams?
4. Integrating technical and non-technical information (i.e. professional skills) in workshop/lesson delivery and assignments so that this content is viewed as interrelated instead of two distinct entities. How do we enable students to see the bigger picture or the overall system that includes required professional skills?

Table 3. Desired course features in a curriculum which includes professional skills training

1. Students (as many as possible) have the opportunity to fulfill a leadership role (especially important for women and other minority groups).
2. Students have the opportunity to assume different roles within a group (e.g., the group leader or the person responsible for a particular aspect of a project such as financial analyst, customer representative, or design lead).
3. Students' personalities and cultural experiences are leveraged.
4. Students are able to self-assess their professional skill development.
5. Peer evaluations are incorporated throughout the duration of the course.
6. Students' listening skills and ability to integrate different ideas are improved.
7. Students' learn how to effectively work in a team and resolve conflicts as a result of both student and faculty facilitated management techniques.
8. Faculty members have the opportunity to lead classroom discussions on various professional skills (e.g. What does it mean to be a good leader? What qualities or traits should a leader have?)

regardless of whether they have been formally trained in professional skill development or not.

3.1 Situational factors

When designing courses, workshops, or seminars, engineering faculty must consider and account for a number of situational factors. Situational factors should influence the design of the course and can include, the context of the teaching and learning situation (i.e. number of students, nature of course delivery, academic level of students, physical environment, course expectations etc.), the nature of the topic, and the characteristics of the learners (e.g. prior knowledge, learning styles, goals etc.) and the instructor (e.g. familiarity with the topic, teaching and learning philosophy). There are questions that exist to help define situational factors for course designers. A modified version of these questions based on Fink [24] and Wiggins and McTighe [25] are presented in Table 4.

These questions, encompassing situational factors, need to be answered prior to the development of course learning objectives. Focusing upon these questions early in course development will inform the creation of successful and purposeful course content. If engineering faculty members find that they are not able to address some of the situational factors, the authors suggest thinking about ways to obtain them. Knowing and deciding-on (where possible) the situational factors as an initial step will help define the next phase of the development, which relates to the content, assessment, and pedagogical aspects of the course. In an effort to provide examples for faculty members, sample responses to these questions are provided in Table 5. These responses are framed within the context of a work-

Table 4. Situational factors to consider when developing a course

1. What learning expectations are placed on this course by the institution or by the profession?
2. How is the course going to benefit the institution? Is course attendance optional or mandatory?
3. What are the salient characteristics (e.g., misconceptions, preconceptions, learning goals, learning styles, demographic information etc.) of the intended learners?
4. What are the backgrounds of student participants?
5. What are students' learning goals, expectations, and preferred learning styles?
6. Will there be prerequisites for course participation, such as a particular type or number of prior experiences?
7. What will be the setting of the course? Are there any physical environment limitations?
8. What types of teaching materials are going to be used?
9. How many students will enroll in the course?
10. How long and how frequently are course meetings?
11. How will the course be delivered?
12. What is the motivation for designing and developing the course? What skills/abilities do students need to improve?
13. What training, if any, associated with the proposed tropic is currently available? Why is this not sufficient?
14. Why should anybody care, listen, and participate in this course?

Table 5. Sample responses to the situational factor questions

- *Salient Characteristics of the Institution*

  The workshop is intended for engineering students in universities in the United States who are interested in learning and developing strong leadership qualities, recognizing and managing important changes, and synthesizing business and social issues within the context of engineering. The workshop is intended to benefit all undergraduates, including students from underrepresented populations and students engaged in experiential learning programs.

- *Salient Characteristics of the Intended Learners*

  Students who chose to attend the workshop are expected to be interested in developing and learning the three targeted attributes. While it is not necessary, students who have held a leadership position or have some leadership experiences during their undergraduate degree would benefit greatly from the workshop.

- *General Context and Teaching Materials*

  The workshop duration is six hours. The number of students is limited to 20 to allow for comprehensive group discussion and extensive attention to students from the instructor. The workshop will be held in a classroom that consists of moveable chairs, a projector, and a computer. A one-hour lunch break session with a keynote speaker addressing the topic of leadership, change, and synthesis is included.

  The teaching material for the workshop revolves around a case-based pedagogy, intended to develop and foster skills of the three attributes. Case studies based on real-world scenarios, developed in-house from research findings, will be introduced at the beginning of the workshop. There is no required textbook or manual for the workshop, however, a list of supplemental references such as books, articles, and papers will be provided to students prior to and during the workshop.

- *Motivation for the Workshop*

  Professional skills, along with technical competencies, have been identified to be important for the development of engineers in the 21st century [27–30]. A recent study that examined the views of engineers from academia and industry have highlighted the importance of leadership, recognizing and managing change, and synthesizing engineering, business, and social perspectives for engineers working in the global society [27]. Furthermore, Daniels [31] identified managing change, ethical leadership, and working with teams as essential curriculum components when training future leaders. Therefore, this workshop introduces and nurtures these skills in engineering undergraduates by utilizing engineering cases and hands-on activities. In the workshop, students will have the opportunity to discuss, reflect, and practice skills learned.

shop for engineering students interested in the application of three attributes: (1) leadership, (2) recognize and manage change, and (3) synthesize engineering and business perspectives. These three attributes are used as examples as they are important qualities for future engineering graduates, but are not explicitly taught at the undergraduate level [26, 27].

3.2 Content, Assessment, and Pedagogy (CAP)

Once situational factors related to a proposed course have been answered, the next steps are to build *content*, decide on the type of *assessment* that will be used to measure the knowledge acquired, and determine the types of *pedagogy* applicable for the course (referred to as content, assessment, and, pedagogy (CAP) throughout this paper). For developing the CAP framework, the authors recommend the use of the "backward design" framework [24–25]. This popular course design approach begins with the end in mind by first identifying what students need to learn, determining how faculty will know that students learned it and finally, designing activities/teaching methods/experiences can be used to facilitate the learning process [25]. The following sections will discuss in more detail the three aspects of CAP.

3.2.1 Building content

The *content* helps to set priorities, to identify significant learning that needs to be included in course development, and to design a course that promotes better understanding among student participants. Therefore, the first stage in curriculum design is to begin with the end in mind by establishing learning outcomes which identify what students should know, what they should understand, and what they should be able to do. It is also necessary to identify what is worthy of understanding, and what questions need to be answered. Generally, there might be more content than a faculty can address in a course. Hence, Wiggins and McTighe [25] suggest using three nested rings to establish curricular priorities (Fig. 1). The inner circle, which is the smallest ring, represents *enduring understanding*. "*Enduring understanding*", refers to big ideas and important overarching concepts students must take away and retain once the course ends. To determine this, some helpful questions are: "What would I like the impact of this course to be on students one or two years after the course is over? What would distinguish students who have taken this course from students who have not?" [24, p. 8]. The middle ring, which includes the smallest ring, is termed *important to know and do* and refers to important knowledge (facts, concepts, and principles) and skills (processes, strategies, and methods) that students must master before the conclusion of the course [25, p. 9]. The largest ring, which encompasses the two previously mentioned circles, identifies general knowledge students should find *worth being familiar with* [25, p. 9]. These three rings (or curricular priorities) help filter the topics that matter most for the course.

Figure 1 is an example of the mapping of Wiggins and McTighe's [25] framework to the leadership,

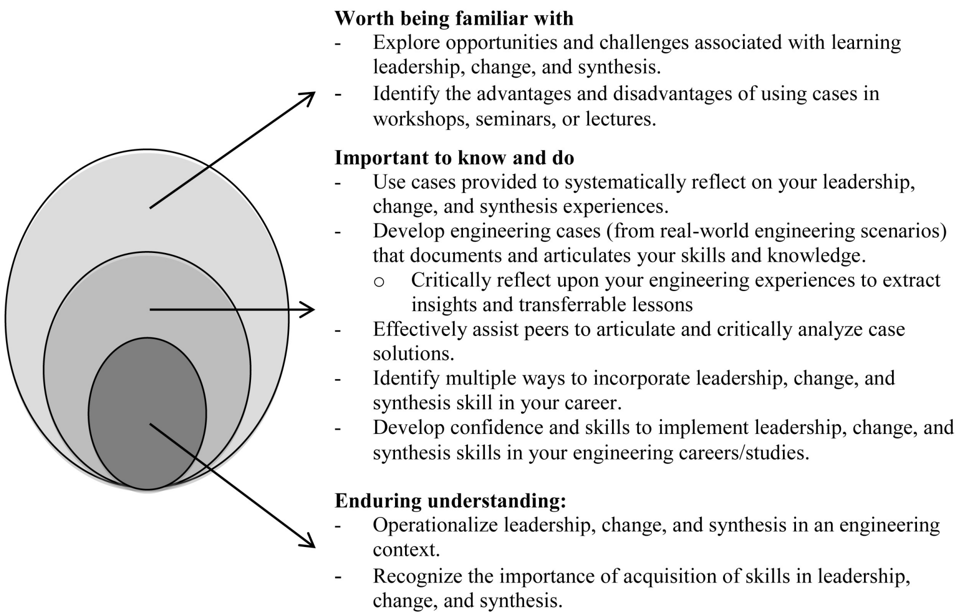

Fig. 1. Application of Wiggins and McTighe's [25] backward design framework for the sample workshop.

change, and synthesis attributes targeted in the previously mentioned sample workshop.

The authors recommend that engineering faculty members develop the three nested rings representing the curricular priorities. While this should be done at the beginning of the course development process, these priorities should be revisited and revised as necessary. This iterative approach fosters deep critical thinking about what is important and what knowledge needs to be transferred to students. In this way, faculty members can increase the efficiency of a particular training course by developing quality content.

3.2.2 Assessment aspect

The second aspect of the CAP framework is *assessment.* Assessment (i.e., collection of evidence of understanding) helps faculty members determine whether students have attained a certain level of competency after completing a course [32]. Sample questions to ask related to assessment include: "How will I know if students have achieved the desired results? What will be accepted as evidence of students' understanding and proficiency?" The goal is to think about the types of assessments that will validate that learning has occurred.

Assessment may occur in various ways and vary based upon the amount of time it takes to generate and to implement them in a course as well as the curricular priority of the content being assessed (e.g. worth being familiar with, important to know, or enduring understanding). It is recommended that faculty use a variety of assessment methods that are summative (formal) and formative (informal). Summative assessments tend to cover more than one topic and to contribute significantly to course grades and formal student evaluation (e.g., midterm or final exams, quizzes, tests, open-ended questions, and projects). Formative assessments are used throughout the course, are related to a specific topic and idea, and may be used by instructors to modify the lesson plan and delivery to gauge student understanding (e.g., feedback on assignments, asking questions, observing students, and conversing with learners through informal dialogue). This combination of assessment approaches is recommended, as "understanding develops as a result of ongoing inquiry" [25, p. 13] and can be guided by frequent assessments.

A formative assessment that may be useful in professional settings and in teaching professional skills is a case study. A case study is a narrative account of a situation, problem, or decision usually derived from actual experience reflecting real-world concerns of managers and professionals [16, p. 375]. Case studies require learners to develop and to evaluate multiple solutions, to consider trade-offs, to generate evaluation criteria for potential solutions, and to choose and defend specific solutions. This type of assessment is especially useful when teaching skills related to ethical issues, design challenges, engineering problem solving, and business scenarios [33–34].

The authors recommend that faculty members develop cases that incorporate professional skills of interest within their respective contexts as an educational and assessment tool. According to Shapiro [35, p. 1], case methods promote the "development of philosophies, approaches, and skills." Cases should include assumptions, constraints, questions, and problems and should identify issues that need to be addressed from the perspective of multiple stakeholders. Students will explore solutions, present ideas and results, and defend their analyses. Faculty and other students can determine the quality of responses while providing insights. The advantage of case studies is that they can convey definitions of skills or attributes through a story and demonstrate how targeted skills can be exhibited in an engineering or managerial context. Furthermore, case studies promote active learning and can be used as a team-based activity [33, 36]. Students apply higher cognitive skills that require them to persuade, communicate, decide, judge and think independently [37, 38], all of which support the development of professional skills among students.

A complementary assessment to solving a case study developed by engineering faculty is to have students generate their own cases. Students could develop cases that are based on their own experiences and could incorporate the skills, attributes, and knowledge gained from the faculty-led course in their respective engineering settings. This will give students opportunities to engage in self-assessment, to evaluate their own learning progresses, to share their cases, and to discuss their solutions with others. For example, a modified version of a "think-pair-share session" could be used. First, students might individually think and develop a case posing a problem and potential solutions. Second, they could turn to their partner and solve each other's case, and then they could discuss and compare solutions with each other. The opportunity exists to share ideas and strengthen each other's cases. Third, the pair can then share their cases with another pair, or with the entire class. The goal is to actively engage every student, share cases, discuss the weaknesses and strengths of solutions, and learn from each other. It is likely that although student-developed cases will differ, a common course theme will form the basis for all developed cases and will guide learning and discussion within the course. During this process, faculty (or an instructional team, such as peer teachers and teaching assistants) can provide relevant feedback and suggestions to students. In addition, this approach provides an avenue for unique experiences of students to be elicited naturally and multiple perspectives can be explored through class discussion. Since learning and developing skills using case studies has been found to encourage learners to engage in contextual and complex engineering problems [39], the authors encourage faculty to use cases as part of their assessment.

Whether a case study or any other approach is used to measure student learning (i.e., assessment), the authors recommend developing an assessment worksheet. The worksheet will consist of two columns- one containing the learning goal and the other presenting information about the assessment method. A learning goal needs to be aligned with the stated curricular priorities, needs to be measurable and obtainable (within the duration of the learning experience), and needs to be stated clearly so that learners can understand. For these reasons, the assessment column is further divided into four sections that consist of (1) general information about the type of assessment, (2) claims about what the faculty anticipates the learner to do, (3) a description of the tasks that students will complete within the assessment, and (4) evidence of learning as a result of the assessments. Faculty is encouraged to develop assessment worksheets for their learning goals and assessment method. Table 6 and 7 contain examples of assessment worksheets for two learning

Table 6. A sample assessment worksheet to explore elements of leadership, change, and synthesis

Learning Goal	**Assessment**
Identify the various components encapsulated in leadership, change, and synthesis within the context of engineering	**General (what type of assessment am I giving?)** • Workshop discussion, oral presentation, and solving a case study
	Claim (An action that the student will be able to do?) • Students will correctly define three targeted attributes- leadership, change, and synthesis. • Students will self-assess and reflect on their leadership abilities; their abilities to recognize and manage change; and their abilities to synthesize engineering, business, and social perspectives.
	Task (What will the students do to provide you with evidence?) • Students will solve in-house vignettes and cases that require them to apply the three targeted attributes. Students will qualitatively analyze and incorporate the three targeted attributes as part of solutions. • Students will present and defend their solutions of the case study to the group. • Students will write the definitions of the three targeted attributes in their own words as informed from the content and discussions in the workshop.
	Evidence (What will the evidence look like?) • Students will begin to correctly identify and to distinguish the three different attributes from one another and will begin to incorporate their learning of the three attributes as part of solutions for vignettes and/or cases.

Table 7. A sample assessment worksheet to develop cases and apply course knowledge

Learning GoalAssessment Develop skills to design open-ended case studies and apply knowledge gained from the course	**General (what type of assessment am I giving?)** • Workshop discussion, oral presentation, written case-study development
	Claim (An action that the student will be able to do?) • Students will be able to develop (either individually or in group) cases that include three attributes and are applicable to their engineering settings. • Students will be able to present and describe their developed cases and explain where and how the three targeted attributes (leadership, change, and synthesis) are integrated in the cases. • Students will develop their own solutions to their developed cases. Solutions should include the application of leadership, change and synthesis in the cases.
	Task (What will the students do to provide you with evidence?) • Students may choose any open-ended real-world scenarios that they may have encountered to develop their own cases. Cases must include questions, answers, stakeholders, detailed descriptions of a scenario (or situation), and explanations of how the three targeted attributes are included in the case. • Students will be asked to present their cases to a group. They are expected to share their cases and to answer any questions proposed by the instructor and other students.
	Evidence (What will the evidence look like?) • There is no right or wrong answer to the cases developed by students. Students, however, should include in their case study information about various stakeholders, current problems, and short descriptions of a situation. They must provide explicit equations and solutions to the engineering problem(s), describe how the three targeted attributes related to the case, and explain or justify how the stakeholders in the scenario should act based on the course lecture, discussion, and prior readings of the three targeted attributes. Students will provide feedback and pose questions during a face-to-face discussion.

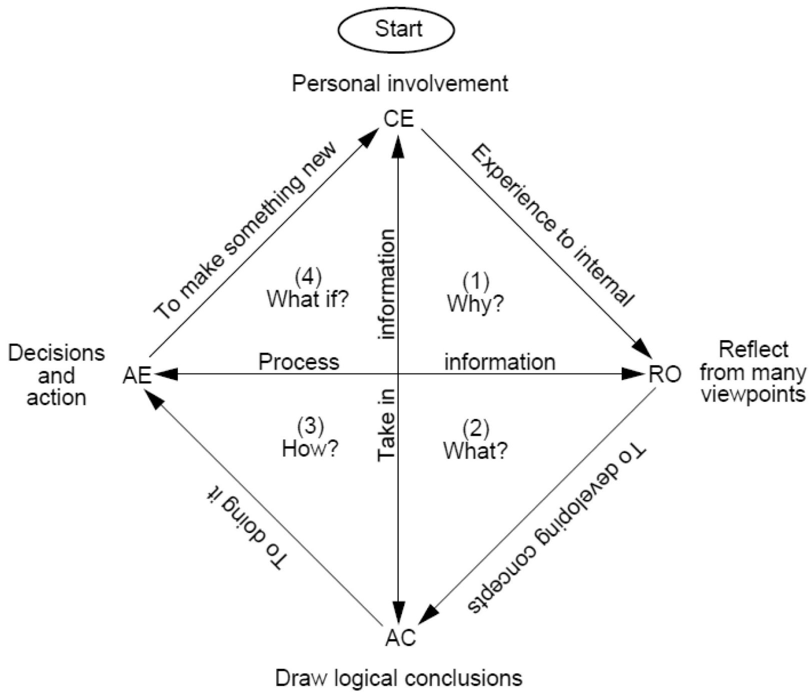

Fig. 2. Modified Kolb's Learning Cycle [43, p. 293].

goals and assessment methods for the sample workshop.

3.2.3 *Pedagogy aspect*

The *pedagogy* aspect of the CAP framework involves planning the learning experiences and instructional methods within a course or workshop. Faculty are encouraged to ask what activities will help students to gain desired knowledge and skills, what will need to be taught and emphasized, how this information should be taught, and what materials and resources are best suited to accomplish the goals. Identifying the content and assessment(s) occur prior to selecting a teaching method, structuring class sequence, and determining resource materials (i.e. pedagogy). This is because identifying the content and appropriate evidence of understanding can help faculty to plan effective instructional activities [25].

One of the challenges that engineering faculty members might find is that students will have a wide variety of experiences and will have various learning style preferences. Students' perspectives on certain professional skills or attributes will vary due to their prior knowledge and competencies. Furthermore, intrinsic factors such as motivation to learn a new subject and extrinsic factors such as demographic differences (i.e., gender, race, ethnicity, nationality, or origin) can all impact students' learning processes. For this reason, selection of teaching methods, together with content and assessment, will become very important for faculty if students are to learn effectively. In this respect, David Kolb's [40] experiential learning cycle provides an excellent framework for developing the pedagogical aspects of a course. According to Claxton and Murrell [41], McCarthy [42], and Wankat and Oreovicz [43], this model is useful for conceptualizing how people learn and for developing courses and training programs.

Kolb [40] developed a two-dimensional learning cycle model of how people learn (see Fig. 2). The first dimension in Kolb's model is active experimentation (AE) and reflective observation (RO). Learners who prefer active experimentation prefer to get things done and to see results, whereas, the reflective observers like to examine the ideas from different angles [43, p. 292]. The second dimension in Kolb's model is abstract conceptualization (AC) and concrete experience (CE). Learners who prefer abstract conceptualization like to conduct logical analyses and prefer abstract thinking and systematic planning. Concrete experimentalists, on the other hand, prefer specific experiences and personal involvements with groups of people [43, p. 292]. Kolb [40] considered these four areas to be the steps required for complete learning.

A possible way to integrate Kolb's learning cycle to the sample workshop as actionable items are listed in Table 8.

Table 8. Integration of Kolb's learning cycles to the sample workshop

- *Experience to internal (Quadrant 1)*
  Through prior readings and references, students first learn why the workshop is important and relevant. Then in the first part of the workshop, students can listen to experts (e.g., senior engineers, engineering and business leaders) promoting the relevancy of the content covered in the course as well as general introductions from the faculty. This will give opportunities for students to understand the importance of the material in the respective context.
- *Developing concepts (Quadrant 2)*
  In the second phase, students will learn and think about concepts. A teaching format similar to a seminar/lecture can be used to present information. According to Harb et al. [44], McCarthy [42], and Svinicki and Dixon [45], seminars can facilitate learners' movement from reflective observation to abstract conceptualization. Students will come to understand the relevant body of knowledge.
- *To doing it (Quadrant 3)*
  According to Wankat and Oreovicz [43], exercises in this quadrant helps to answer students' questions about how something works. Some of the teaching and learning activities in this quadrant include homework problems, simulations, demonstrations, experiments, problem solving activities, and case studies. The faculty can facilitate students' efforts through demonstration, although the work will primarily be done by the learners.
- *To make something new (Quadrant 4)*
  In the fourth quadrant, students can teach themselves, ask what-if questions, and apply the knowledge that they have gained from the workshop. Students can create their own experiments. The faculty members might ask students to discuss, generate questions, analyze, and critique studies and encourage interactions between students that allow them to teach themselves and others.

4. Synthesis and implementation

The sections above have laid the foundation for developing various components of designing a particular lesson or an entire course. The next step is to ensure that all components are aligned and ready for the implementation. Situational factors, content, assessment, and pedagogy activities should all reflect and support each other. One of the ways to ensure that the components are coherent is to develop a course structure that divides the contact hours into segments that focus on key topics and that determine details about the sequence and the potential number of hours, days, weeks, or class sessions to engage in each topic [24]. The opportunity exists for engineering faculty to be flexible and creative in this phase. However, it is important to recognize that as new concepts and topics get introduced, students will need time to understand, observe, and put elements of this framework into practice. The best way to prepare for the course is to imagine how each section will be executed and how it will progress. When the course is implemented for the first time, constant observation by the faculty will be necessary. They should listen to the feedback from students and adjust the pace and the content of the course as needed. As the faculty offers the course multiple times, the implementation phase will become easier due to past experiences and to the application of the feedback collected from the learners at the end of each course. Table 9 is an example of the structure for the sample workshop.

The structure of the workshop shown in Table 9 is designed in a deliberate way. The first part of the workshop introduces three professional skills ((1) exercising leadership, (2) recognizing and manage change, and (3) synthesizing engineering, business, and social perspectives within engineering) that the students are to focus on during the workshop along with the outline and the goals of the workshop. The workshop then transitions to "Morning Session I," where the faculty provides the definitions of leadership, change, and synthesis. The faculty refers to reference articles that students were asked to read prior to the workshop. Collaborating with a research team, the faculty previously developed four scenarios closely affiliated to leadership, change, and synthesis (see Appendix A). The scenarios are termed "vignettes" in the workshop, and they are developed within the context of a student-led design project which presents a common under-

Table 9. A course structure for a designed sample workshop

Development of Leadership, Change, and Synthesis Practices in Undergraduates

Time—9 AM to 3 PM

Discovery Learning Research Center

Time	Event
9:00 AM	Introduction—Overview, goals, and learning objectives
9:40 AM	Linking leadership, change, and synthesis to courses • Course exercise
10:10 AM	Morning Session I—Scenario exploration • Four scenario examples
10:30 AM	Coffee break
10:45 AM	Morning Session II—Report outs and case study introduction • Scenario report outs • Introduction to problem-based case studies • Translating general cases to discipline-specific situations
11:45 AM	Lunch/Keynote
1:00 PM	Breakout group • Case-study development
2:00 PM	Coffee break
2:15 PM	Report outs & next steps • Share developed case studies • Next steps (expectation for students)

graduate experience. Multiple iterations are made on vignettes to ensure that the stakeholders and different contexts are clearly defined. To tap into professional skills, questions are included that aid student reflection on how they would act in the particular scenario described in a vignette. Later in the session, the student groups are asked to report and discuss their solutions with others. The vignettes serve two main purposes: (1) to help students clearly understand the definition of the three targeted attributes within an engineering context and (2) to begin to form their ideas on how these attributes may apply to their personal settings.

The workshop then transitions to introducing case studies. According to Wankat and Oreovicz [43], engineers are classified as ''convergers''. The preferred learning style for convergers is quadrant three in Kolb's learning cycle where they have the opportunity to design and conduct experiments. Wankat and Oreovicz [43] suggest that since convergers need to relate theory to practical applications, case studies are particularly useful if a good case is designed. To this end, students are then provided with information concerning the components for good cases and how cases can help develop some of the definitional features of leadership, change, and synthesis. The faculty provides a discipline-specific case as an example. Then, as part of the lunch session, an expert is asked to provide a keynote speech on how cases can foster the development of skills and abilities that link to various learning outcomes. The afternoon session consists of students working individually to develop cases based on real world scenarios that supplement content from their courses. Finally, students are provided with the opportunity to synthesize information from the day.

In the implementation of a workshop or course, faculty will have to make constant adjustments to the initial workshop plan. Sometimes, the workshop will run behind schedule, given the rich discussions between students and the faculty. Sometimes, additional time will be needed to confirm that targeted content and definitions are interpreted clearly. Every time there are unexpected delays, the workshop schedule will have to be adjusted and modified to ensure that all curricular priorities are covered. Constantly reviewing the progress of the class and adjusting to the students' needs is one of the key roles that the faculty has to make.

5. Implications for engineering faculty

Engineering faculty may use the strategies in this paper to develop in-house professional skills training courses that are suitable for faculty's individual settings and goals. Following the steps in the paper can alleviate some of the challenges identified earlier in Table 1 and 2. For example, having students develop their own case could exploit/utilize students' unique past experiences, and asking students to share the case with others could result in a unifying experience for all students in a classroom. Furthermore, answering situational factor questions (Table 4) and applying Kolb's experiential learning cycle (Fig. 2) could ensure faculty develop a course, with professional skills training components, that is relevant and engaging for students at different levels of undergraduate education. In addition, the *Content* aspect within the CAP framework (specifically Wiggins and McTighe's backward design framework in Fig. 1) will help faculty balance professional skills training and technical content instruction in an engineering classroom.

With respect to the example workshop used throughout the paper, the content and enduring understanding lie with the three targeted attributes of leadership, change, and synthesis. The content covers the operational definitions of the targeted attributes, recognizes the important skills within these targeted attributes, and identifies ways to teach future engineers these attributes. In order to measure students' knowledge gains, assessments such as discussion, presentations, and solving and developing cases are included. These assessments ensure that students describe and analyze topics related to the targeted attributes, work in teams, interpret various cases, and develop their own cases that can be used in their respective engineering settings. Finally, the pedagogical approach of Kolb's learning cycle is used in the workshop as it motivates students to authentically engage with workshop content, simultaneously familiarizing themselves with the three targeted attributes while learning how to develop cases. In this engaging and student-driven learning environment, professional skills such as leadership, communication, collaboration can be developed and honed.

6. Conclusion

This paper seeks to help engineering faculty make sense of a sound curriculum design process and develop their own short courses that teach professional skills to engineering undergraduates. For every instructor, the design process and the alignment of CAP introduced in this paper will be an iterative process that will require refinements and modifications in both the course preparation and implementation phases. In addition, it is suggested that case studies are a suitable assessment and instructional strategy that can be utilized within the CAP framework to teach professional skills. Armed with these tools, faculty can build confidence in their ability to incorporate professional skills instruction into their courses. With a committed and open-minded approach to considering the positive and negative aspects of implementation and a willingness to adapt accordingly, the learning experiences of students can be maximized.

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Appendix A

Scenario Exploration for Engineering Undergraduates

A classroom has been broken down into teams selected by the professor on the basis of your past performance. Each team is asked to complete a renewable energy project to work on over the semester, carrying out the design, manufacturing, and implementation phases of the project. The project involves theoretical, analytical and experimental inquiry. Individual team members are expected to work on different aspects of the project both individually and in groups. One of the goals of this student-lead project is to have all students to take both personal and collective responsibility for the project's success.

It is expected that the day-to-day management of the project will be the responsibility of the team members. Student teams are expected to ensure the best use of resources (i.e., human and physical capital) and that the project reaches a satisfactory conclusion. In order to ensure that the success of the project can be measured by the teaching assistant and professor, some requirements exist for student teams. For example, student teams are required to meet with the teaching team once a week to report their progress. All students in the team must attend every meeting or provide explanations for any absences to the group.

Every team will designate a chairperson and secretary for the weekly meetings. The two positions will rotate around the team so as to assure all members contribute and have an opportunity to engage in leadership roles. It is up to the team to decide how and when the position will rotate. The chairperson is responsible for the conduct of the meeting and the overall project for the amount of time he or she is in the position. The secretary is to produce the meeting agendas for the meeting and will deal with any other administrative tasks for the week following the meeting.

The final project assessment is based on both students' work as members of the team and their individual contributions. As a member of the team all students have a responsibility to ensure that each member contributes to the best of their ability as reflected in their final deliverable(s).

Vignette 1

"Assuming Leadership on a Student Team"

Few days after the semester has started, you realize that your team consists of people who have not had much leadership experience. No member in your team wants to be the chairperson or the secretary. Even if a student takes on a leadership role, he or she has difficulty making any decision related to the progress of a project goal. All members are clearly not comfortable taking the responsibility and making the final decisions that could impact the group and the overall success of the project.

1. What can you do as a member in this team when this kind of situation arises?
2. Assume that the composition of the team consisted of two international students (i.e., a Chinese female, a Korean male, a U.S.-born white female, and a Hispanic male). Would you handle the situation differently? Why or why not?

Commentary for instructor: Development of a leader

The first scenario aims to teach students of intrapersonal competence associated with the development of a leader including, confidence, motivation, courage, and being proactive.

Vignette 2

"Everyone's a Leader"

You notice that your team consists of members where everyone wants to be the leader, wants to take on the responsibility, and wants to make the final decision with respect to all aspects of the project (including the design, development, presentation etc.). Everyone in your team feels that he (or she) is the leader who has the ability to take control and guide the team throughout the semester. Even if the leadership position is shared amongst all members in the group, whoever holds the position is dictating and is not willing to listen to any other members in the team. The situation further deteriorates as semester passes as most of the members not afraid to voice their opinions.

1. What can you do as a member in this team in this type of situation?
2. How would you encourage your peers to demonstrate leadership, change, and/or synthesis attributes?

Commentary for instructor: Development of a leadership

The second scenario focuses more on building relationships among individuals to enhance cooperation and to exchange resources in generating values. The aim is to explore various interpersonal skills. Interpersonal skills are defined as the ability to understand people by building trust and respect (Gardner, 1993) [46]. The key to this relational model is commitment in the form of mutual obligations [47], for example, *trust, ability to listen, integrity, and responsibility.*

Vignette 3

"Exploring Broader Impacts"

After few weeks into the semester, your team has finally determined ways to effectively work as a team. Your team has selected a project of harnessing solar energy to provide essentials goods to people in a poor rural village. This project would involve your team building solar home system, consisting of electric lanterns, solar cooks, and solar lighting systems. From your prior experience and knowledge you know that the village have generally very little material wealth and are often without electricity. You know that the solar home system that your team is building will change and impact the lives of these villagers. However, your peers are not aware of any social and/or environmental impact that the technology with have on the villagers.

1. How can you help your peers see the bigger picture of the engineering impact and/or the broader impacts of the project?
2. How might you implement your thoughts into your current classroom or setting?

Commentary for instructor: Development of a synthesizer

The third scenario aims to show that engineers' activities will have direct bearings on the welfare of large segments of society. The solar energy project helps students to understand the real impacts their work will have on real people. The project shows a real-life application where technology can be used to make the greatest difference to people's living standards. The goal is to bring social, economical, and environmental consequences from implementing engineering work to students' attention.

Vignette 4

"Rethinking the Solution"

Upon the completion of the project, your team presents the work to sponsors and various organizations. The product design is well received by the sponsors. They are impressed and want your team to build the prototype. They promise your team a financial support and an opportunity to travel to the village to test the system. One constraint however, is added to the team from the sponsors. The sponsors request the team build the system using only the materials and tools that could be found in the village. The team is asked not to use anything that could not be found or manufactured outside of the village. This is not an easy issue to solve for your team, as number of methods and techniques used in the design could not easily be replicated outside a commercialized area.

1. How can you help your team work with this additional constraint?
2. What other issues do you believe your team needs to address?
3. What are some of the general issues, costs, and perhaps politics that your team may encounter? How would you navigate around these issues?

Commentary for instructor: Development of an adaptor to change

When practicing engineering, physical, economic, and political constraints always exist [48]. Constraints also include sudden unexpected changes to personnel, technology, or priorities. It is known that "the engineer always seeks the best change within the available resources" [48]. Usually, a number of solutions exist, each limited by different constraints. Successfully recognizing and managing change to engineering work is the goal of this scenario.

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