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Leadership and Ethics in Undergraduate and Graduate Curricula at a Hispanic-serving Institution

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Abstract

Leadership and ethical behavior are desired character traits of engineering graduates, however they are frequently not the subject of significant instruction in engineering courses. The importance for engineers to possess these traits is demonstrated by their inclusion in ABET student outcomes. Therefore, leadership and ethics are important subjects of instruction for undergraduate and graduate engineering education. At Texas A&M University-Kingsville (TAMUK) a Hispanic-serving institution, aspects of leadership and ethics are explored in the capstone senior design course sequence for chemical engineering, and in master's thesis and doctoral seminar courses. Instruction in leadership is achieved primarily through project- or research-based learning, while instruction in ethics is achieved by case study review and discussion. The objective is to present how these sometimes-overlooked topics are addressed at an institution with a majority Hispanic student population, noting that Hispanic graduate engineers are underrepresented in the engineering workforce.

Introduction

The characteristics of leadership and ethical behavior are not considered as principal instructional topics in engineering curricula, although they are important traits for engineering graduates to possess[1,2]. The public relies on engineers to design facilities that the public uses, interacts with, or is exposed to in a manner that ensures high standards of safety. This public reliance on engineer's instilling safety in design is a primary raison d'etre for professional engineering licensure in states across the US. For young graduate engineers, leadership is commonly an employer-desired trait that develops over time, and an important one for graduate engineers to demonstrate in their growth, and in their experience represented in the application for professional engineering (PE) licensure. In a similar vein, ethical behavior is expected of engineers by employers, and is routinely reflected upon in annual reviews and corporate training, and additionally is an important aspect highlighted in the professional engineering licensure process, as well as in the PE licensure maintenance (professional development) process. The importance of these traits for engineers is also indicated by their inclusion in ABET student outcomes (SOs) 4 and 5, which all accredited undergraduate engineering degree programs must demonstrate is consistently achieved by their

students[3]. It is incumbent upon educators responsible for developing the leadership and ethics traits in their engineering students to know the most effective means to accomplish such instruction[3].

The need for leadership and high ethical work standards amongst engineering graduates moving into industrial professional positions has a renewed emphasis in industry as a result of corporate scandals of the late 1990s and 2000s[1]. Industry employers expect new engineering graduate hires to perform their work in an ethical manner[2]. Different methods of developing leadership and ethics skills, such as through technical writing[4], project-based learning, case study review[5], and promotion of ethical behaviors[1], have been developed and implemented in different engineering programs. Therefore, instruction in leadership and ethics is an important non-technical facet included in undergraduate and graduate engineering education. Within the chemical engineering program at TAMUK, these traits are principally developed in the undergraduate capstone courses and in a graduate seminar course. Since TAMUK has a majority Hispanic student population, and since Hispanic engineering students typically have insufficient role models in their path to degree completion and thereafter professional employment, the manner in which instruction for these particular employer-desired traits is accomplished is of current interest. The goal of this paper is to present the methods used in our chemical engineering program for instruction of the non-technical traits of leadership and ethics at both the undergraduate and graduate level, make a case for this instructional effectiveness in our program at our majority Hispanic population university, and to invite feedback on this approach for our Hispanic majority university.

Instruction in Leadership

At TAMUK, aspects of leadership and ethics are explored in both the undergraduate and graduate level programs. Table 1 presents a tabular overview of where and how these traits are presented in courses in our programs. Since these facets of engineering professional growth are not typical quantitative math or engineering topics that constitute the majority of material covered in engineering academic programs[2], instruction in these areas is performed in limited bits in only a couple of courses. Specifically, leadership is discussed in the context of group projects and teamwork in the capstone senior design course sequence for chemical engineering (courses CHEN 4316 and CHEN 4317), while ethics is discussed, and ethic case study reviews assigned, in a separate unit in the same course. At the graduate level, these topics are encountered in a doctoral level seminar and research integrity course. Specifically, ethics is discussed through case study reviews in a manner similar to the undergraduate capstone course, however the plagiarism issue is also discussed in detail, since this is an ethics related issue of very high importance to for graduate students writing research proposals, theses, and dissertations.

Table 1. Overview of Leadership and Ethics Taught in CHEN Engineering Courses

Course Environment		Engineering Trait	
Course	**Course Level**	**Leadership**	**Ethics**
Capstone Design Course Sequence in CHEN	Undergrad Seniors	Project management, including team leadership	Case study review, ethics decision-making tools
MS Thesis Research Course	MS candidates	Self-motivation and determination necessary for thesis progress	Plagiarism in scientific research
Seminar and Research Integrity Course	PhD candidates	Self-motivation and determination necessary for dissertation progress	Case study review, ethics decision-making tools, plagiarism in scientific research

In the second undergraduate capstone course, the facets of leadership are presented within the framework and content of a "teamwork" lecture. Thereafter, the need for leadership as an element for effective project management is espoused. The instructor encourages students to utilize the team leader role in their senior design team project, so as to have an orderly process for delegation and oversight of technical tasks. The project teams are also recommended to have the team leader role rotate amongst all team members over the course of the semester. Based on the instructor's observations of previous year teams, some team members take up the leadership role more readily than others, even to the point of some teams asking whether a current team member can remain as leader for the rest of semester. Most all team members particularly appreciate when one team member demonstrates strong leadership skills. Not surprisingly, these groups typically demonstrate the greatest effectiveness through the course of the semester, and are less likely to exhibit semester end crunching to complete their project. Scores for the leadership-related student outcome (ABET SO 5: An ability to *function effectively* on a team whose members together *provide leadership*, create a collaborative and inclusive environment, and establish goals, plan tasks, and meet objectives [emphasis added]) are presented for the courses CHEN 4316 and 4317 in Table 2. In scoring ABET SOs on the 1 to 4 scale, a score of 3 is considered as the margin below which some corrective action or curricular improvement may be needed. The results for SO 5 presented in Table 2 are all close to the 3.0 value over the academic periods 2017 to 2021. Note that assessment of this particular SO involves other teamwork aspects in addition to leadership, such as collaboration, and task planning and execution. Improvement in these marginal scores is currently sought in our program through revision of the performance indicators that our department uses to assess SO 5, which will allow a more targeted and meaningful assessment that is expected to lead to identification of separate facets of teamwork that required targeting for instructional revision during future course offerings.

Table 2. ABET Student Outcome Scores Related to Leadership and Ethics

Component	Course	AY '17-'18	AY '18-'19	AY '19-'20	AY '20-'21	AY '21-'22
Ethics (ABET SO 4)	CHEN 4316	ND	3.90	3.76	3.31	ND
	CHEN 4317	ND	3.50	3.88	ND	ND
	CHEN 4120	NC	NC	NC	3.33	3.59
Leadership (ABET SO 5)	CHEN 4316	ND	3.02	3.09	2.92	ND
	CHEN 4317	2.93	3.08	3.09	3.20	ND
ABET Student Outcome scores are determined on a range of 1 (low) to 4 (high) NC: no class ND: no data, SO was not assessed during that course offering						

The development of leadership traits in the graduate research environment is not so much focused on leading teams of people working on a common project, but rather focuses on leadership embodied by the independent research work of the graduate student. The two principal elements of graduate leadership in our program are: a. independent, self-directed research work; b. periodic opportunities for supervising work of undergraduate students in instances such as teaching assistant duties that may involve the engineering lab environment. Specifically, in the PhD seminar and research integrity course CHEN 6303, the students are led through a series of research assignments related to literature search and writing on their dissertation proposal. Independent research work, viewed as self-leadership, is extensively discussed and encouraged throughout this series of tasks using a mentoring approach by this instructor. In a recent offering of this PhD course, a cohort of 19 students earned scores represented by averages ranging from 86 to 94 over five separate but related sequential assignments. At the Master's level in our chemical engineering program, leadership is not addressed as a separate instructional topic in any particular course, although the mentoring approach described in the doctoral course described above is also used with the Master's level graduate thesis students.

Instruction in Engineering Ethics

Ethics, in the context of engineering design, analysis, or construction work, is taught in the capstone design courses by introducing engineering-related ethical canons, such as those set forth by National Society of Professional Engineers (NSPE), American Institute of Chemical Engineers (AIChE), or other similar professional organizations, and then through introduction of decision-making tools or procedures that can be used in ethical dilemma situations. Thereafter, the instructor leads students in discussion of historic case studies in which ethical lapses by engineering designers or project teams resulted in system or equipment failures, and threats of human injury or loss of life[6,7]. The students and instructor work together to complete an ethical decision-making tool for specific case studies. This approach to studying engineering ethics may appear antiquated, however it is a tried and true method that is still used extensively[5,2], as

evidenced by the plethora of engineering ethics chapters in engineering books, as well as complete books on the topic[6,7]. Scores for the ethics-related student outcome (ABET SO 4: An ability to *recognize ethical and professional responsibilities* in engineering situations and informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, societal contexts [emphasis added]) are presented for the courses CHEN 4316 and 4317, along with undergraduate chemical engineering seminar course CHEN 4120, in Table 2. The results for SO 4 presented in Table 2 range from 3.31 to 3.90, and thus are significantly above 3.0, indicating that program objectives for introduction to engineering ethics have been consistently achieved at an acceptable level over the period 2017 to 2021. At the graduate doctoral level, the same approach to ethics instruction is incorporated into the seminar and research integrity course. Additional ethics-related discussions are held at the graduate level, both in the doctoral seminar course and in the Master's thesis course, on the topic of plagiarism, since this is a high concern for graduate students in their myriad writing efforts.

This instructor has observed recent ethical lapses involving the academic work of both undergraduate and graduate students over the last several years. In particular, the less supervised environment of virtual learning attributable to the COVID pandemic that began here in March 2020 led some students to test the boundaries of unethical behavior, as by cheating (copying other student's answers) on exams administered virtually and through plagiarism (detected by Turnitin document review) in the preparation of graduate thesis documents. In these several cases uncovered by this instructor, he promptly informed each student of his finding of exam cheating or plagiarism, asked the student if they had a rebuttal or explanation, and then notified the department chair, College Dean, and Dean of Students of the specific violation. The instructor also assigned a failing grade to the student for the particular assignment. In consultation with the department chair, the instructor brought these specific academic violations to the attention of other students in the same course or same graduate program, without specific mention or identification of the violators, so as to serve as a deterrent against similar violations by others. Return to majority face to face instruction in the fall 2021 semester year appears to have led to a lower incidence of these cheating instances.

Summary and Conclusions

Leadership in an engineering project environment is taught to senior-level undergraduate students within the greater context of teamwork and project management of their senior design projects. Based upon the ABET scores over the last several years for the SO 5 student outcome, a greater emphasis should be placed on the leadership role in undergraduate team projects, in order to improve the scores to a desired level, namely consistently well above 3.0. A revision of performance indicators associated with each individual ABET SO, which is a change attributable to a recent ABET accreditation visit in fall 2021, is expected to shed a higher level of detail on whether the leadership facet of the ABET SO 5 requires further attention for continuous

improvement, in order to achieve the desired higher scores for our majority Hispanic student population.

The ABET scores for the ethics-related student outcome (SO 4) indicate the current approach to ethics instruction is producing desirable and consistent results for our majority Hispanic undergraduate students. The effectiveness for graduate students is expected to be the same as for the undergraduate cohort, although direct evidence from course assessments is not available because the graduate program is not subject to the ABET accreditation. A further measure of success in this approach to ethics instruction is the fact that a former undergraduate student in our program contacted this instructor several years into the student's professional employment to discuss his options in a recent ethical dilemma in his workplace. Ethical lapses among young professional may become more prevalent as work from home conditions continue or prevail post-COVID pandemic.

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