AC 2010-239: ACHIEVING CIVIL ENGINEERING BOK2 OUTCOMES OF GLOBALIZATION, LEADERSHIP, PROFESSIONAL AND ETHICAL RESPONSIBILITY AND TEAM WORK IN A GENERAL EDUCATION CLASS

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Achieving Civil Engineering BOK2 Outcomes of Globalization, Leadership, Professional and Ethical Responsibility and Teamwork in a General Education Class

Abstract

Our college has recently developed a new course titled "Moral Leadership in a Technological World." The class was created to address the need to help educate leaders who understand and are prepared to address the emerging global world environment from an integrated moral, technical, and social perspective. This course effectively encompasses the civil engineering BOK2 outcomes of leadership, globalization and ethics. In addition, the theory and practice of teamwork is a major component of the class. The course has been approved by the university to fulfill students' general education requirements in both social science and global and cultural awareness. Our civil and environmental engineering department now requires all majors to complete this class. Since the course is an approved general education class any student registered at the university can enroll. Since the motivation for the course originates from incentives at the college level, the teaching load is distributed among five engineering and technology units within the college. Open university enrollment for the course is leading to very large sections. However, the chance to teach these important concepts to the general university student body provides a unique opportunity to introduce a broad cross section of students to critical global issues from an engineering perspective.

This paper begins by providing motivation from both the National Academy of Engineering and the American Society of Civil Engineers to engineering educators to provide more content in leadership, professional ethics, knowledge of global technical issues, and a more complete understanding of the world's cultures. These topics aid the engineering professions in effectively working in the global arena and becoming more engaged in public activities. The paper continues by describing the university criteria the course must satisfy to be approved to fulfill both Social Science and Global and Cultural Awareness general education requirements. In addition, the various course modules that address the Civil Engineering BOK2 outcomes of globalization, leadership, professional and ethical responsibility, and teamwork are explained. Evaluations of these modules are shown. The college effort to effectively prepare the requisite faculty to teach the course is also described. Finally, potential embedded indicators are suggested that could be used for ABET assessment.

Key Words: BOK2, Globalization, Leadership, Teamwork, Ethics, Professional Responsibility

Introduction

Many technical and professional societies, as well as visionary academic leaders, are calling for a new emphasis on skills and characteristics that will distinguish the professional engineer of the future. Included in these skills and characteristics are leadership, ethical responsibility, global awareness and the ability to effectively function on multidisciplinary teams. In 2004, the National Academy of Engineering (NAE), in their report The Engineer of 2020 clearly outlined the attributes they felt were crucial for the engineering graduates of the future. This document stated ". . . attributes needed for the graduates of 2020 . . . include such traits as strong analytical skills, creativity, ingenuity, professionalism, and leadership."[1] In their follow-up report, Educating the Engineer of 2020, NAE encouraged engineering educators to incorporate more education in the topics of leadership principles, professional ethical behavior, knowledge of global technology issues, and understanding of the world's cultures in order to facilitate working in a global arena and engagement in civic activities.[2] The popular author Thomas Friedman, in his bestselling book The World is Flat[3], effectively described the current state of globalization and its effect on the engineering community. Friedman has recently articulated a technical leadership challenge in his work Hot Flat and Crowded.[4] James Duderstat, President Emeritus and University Professor of Science and Engineering, University of Michigan issued a concern for how engineering professionals and educators view leadership when he said: "Today's engineers no longer hold the leadership positions in business and government that were once claimed by their predecessors in the 19^{th} and 20^{th} century, in part because neither the profession nor the educational system supporting it have kept pace with the changing nature of both our knowledge-intensive society and the global marketplace."[5]

The American Society of Civil Engineers (ASCE) is an active proponent for strengthening the abilities of professional engineers by enhancing their skills in the areas of leadership, professional and ethical responsibility, and teamwork. The ASCE document The Vision for Civil Engineering in 2025[6] states that civil engineers must be "entrusted by society to create a sustainable world and enhance the global quality of life." In addition it articulates that "In 2025, civil engineers will serve as master builders, environmental stewards, innovators and integrators, managers of risk and uncertainty, and leaders in shaping public policy." Academia is challenged in that "Colleges and universities must examine their curricula as they relate to the future civil engineer so advancement toward the vision can be realized. In the U.S., ABET, Inc would be a targeted partner in this area." In the recent ASCE document, Achieving the Vision for Civil Engineering in 2025 – A Roadmap for the Profession [7] tactics to achieve the stated outcomes are presented.

In 2004, ASCE published an initial Body of Knowledge (BOK)[8] of 15 outcomes deemed to be requisite to becoming licensed to practice. ASCE subsequently enhanced the initial work to BOK2[9] which now includes a set of 24 outcomes. These 24 outcomes are couched in the six levels of attainment specified with Bloom's Taxonomy.[10] These levels of attainment are:

1. Knowledge - the remembering of previously learned material.
2. Comprehension - the ability to grasp the meaning of material.
3. Application - the ability to use learned material in new and concrete situations.

4. Analysis - the ability to break down material into its component parts so that its organizational structure may be understood.
5. Synthesis - the ability to put together to form a new whole. This may involve the production of a unique communication, a plan of operation (research proposal), or a set of abstract relations (scheme for classifying information).
6. Evaluation - the ability to judge the value of material for a given purpose.

ABET, the Accrediting Board for Engineering and Technology, stipulates eleven (i.e. a-k)[11] outcomes for all engineering programs including (d) an ability to function on multidisciplinary teams, (f) an understanding of professional and ethical responsibility, and (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. In addition, ABET criteria for Civil Engineering programs include the requirement that "The program must demonstrate that graduates can … explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure."

Regarding ethics, Colby and Sullivan[12] presented results on the effectiveness of undergraduate engineering education in supporting students' ethical development. They pointed out that teaching engineering ethics in a university environment was done generally by 1) stand-alone courses, 2) brief class discussions that are instigated in connection with the subject matter of the course and 3) with modules inserted in existing classes – most often in capstone courses. They warned that "there are also risks in relying on general philosophy courses as students' only systematic exposure to ethics. Especially when these courses are taught outside the school of engineering, there is a risk that students will not know how to connect what they learn to their own work." They also point to a finding of Austin that "engineering produces more significant effects on student outcome than any other major field."[13] Thus there is growing support that ethics should be taught within an engineering curriculum.

Based on these realities for our current and future students, our college administration is promoting a focused academic effort to include the areas of leadership, innovation, global awareness, and character development as well as technical excellence within all of the ABET programs within our college. All of the above described incentives have provided both a challenge and an opportunity to develop an effective approach to include these new skills within our curriculum.

Development of a University General Education Course

To fulfill a portion of the University General Education requirements, students at our institution must complete at least one specified Social Science (SS) course and one specified Global and Cultural (GCA) awareness course. It is possible that a single course can meet the requirements for both Social Science and Global and Cultural Awareness. Our college, upon developing an initiative in leadership, ethics, and globalization, believed that a new University General Education course could be developed that would address these three topics.[14] Such a course would allow engineering students to gain skills in these areas without increasing graduation requirement credit hours. Such a course would also serve the general university student body by teaching them crucial, but non technical engineering subjects. We have begun teaching such a course and have chosen to name it "Moral Leadership in a Technological World."

University criteria must be satisfied and approval by our institution's Faculty General Education Committee (FGEC) must be obtained prior to a class being sanctioned for General Education credit. For a course to meet "Social Science" criterion, it must provide a student with explicit knowledge and experience of both the strengths and the weakness of applying the scientific method to a particular set of problems and issues within a given discipline of the social sciences. Social Science scientific principles and reasoning requirement objectives include: 1) providing a framework of scientific principles to illustrate the processes of science, 2) exposing students to the excitement of discovery by examining the thinking process that guided some important scientific discoveries, 3) introducing students to the scientific method by analyzing real-world science-based problems, 4) provide tools to evaluate scientific data and claims so students can make rational decisions on public-policy science issues that affect their community, 5) avoid content-driven presentations that are encyclopedic in nature, 6) developing assessments that encourage students to demonstrate their knowledge of scientific reasoning through appropriate use of written, verbal, and/or numerical skills, and/or 7) providing opportunities to reflect upon possible competing claims between science and religion. Social science involving human behavior arguably represents the most complex and varied phenomenon to which the scientific method may be applied. The disciplines of the social sciences use various assumptions and methods of analysis in their efforts to explain the structure and behavior of individuals, families, and public and private institutions. Courses fulfilling this requirement are expected (to) devote significant portions of the course to the following:

- An examination of the methodology and approach of a particular discipline within the social sciences;
- Identification of the assumptions about human nature used by a given discipline;
- The basic theory or models used to examine human behavior in that discipline;
- An evaluation of evidence supporting or contradicting these theories and explanations;
- Implications of this discipline's approach and findings for individuals, families, society, and public policies.

Our new course addresses items 1 and 3-6 as well as all of the five bulleted items in the above paragraph. The discipline of our course is engineering and technology and the topics addressed that meet the criteria of the five bulleted items are moral reasoning, teaming, leadership, and global technology development.

The university global and cultural awareness requirement objectives are:

1. Students will acquire informed awareness of either a) a culture outside their own, or b) the interplay of cultures, languages, and/or nations at an international level.
2. Students will experience thoughtful reflection on the above, as demonstrated in a

structured, guided manner under the direction of a faculty member. Evidence of reflection implies written or spoken analysis that will include a consideration of the student's own responses to the culture or global issue, often involving comparison, and will demonstrate informed awareness.

3. Students will develop greater empathy and charity, and begin to gain a global perspective, by learning to see themselves from another's point of view.

Our new course addresses 1b) and both 2 and 3 of the numbered items above.

A key component of this course, satisfying the GCA requirements, is a multi-phase activity called the "Small Helm Project." This activity effectively engages students in a problem solving approach to ethical and/or technological problems in the global arena. The project incorporates several educational objectives while exposing students to significant global issues that face the engineering and technology community.[15]

The student outcomes specified for our new course are:

1. Understand principles of effective leadership and be introduced to theories upon which the principles are based.
2. Understand crucial characteristics of leadership as expressed in the engineering and technology college model and strive to develop those characteristics in their professional and private lives.
3. Understand the importance of developing organizational vision and be familiar with principles of strategic planning.
4. Understand the value of people and be committed to the realization of the human potential.
5. Understand and be able to demonstrate effective interpersonal and team skills.
6. Understand and commit to practice the appropriate discipline code and other professional codes of ethics.
7. Learn an approach to moral reasoning and a dilemma resolution procedure based on gospel principles and the scientific method.
8. Demonstrate a sense of professional community and understand and commit to act with consideration for the welfare of the global community and society.
9. Develop an appreciation for other cultures and an understanding of how cultural factors and other forms of diversity influence communication, teamwork, and the practice of technical disciplines across the globe.
10. Understand the meaning of globalization and its potential to impact societies and the practice of their disciplines.
11. Develop an appreciation for life-long learning as an essential aspect of successful leadership, global competence, and ethical behavior

As indicated in references 12 and 13, there is good evidence that subjects such as ethics can and should be taught within an engineering curriculum. With the growing call for leadership and teamwork from both ABET and ASCE, teaching these subjects will likely become more prevalent in engineering curricula. The engineering faculty who developed the course described in this paper have spent many years teaching engineering ethics within the college curricula and have welcomed the opportunity to present topics of both traditional and principle based ethics, coupled to structured professional engineering codes of ethics to the broader campus community.

Comparison of ABET, BOK2, and New Course Outcome Levels.

Earlier in this paper we defined the six levels of attainment identified by Bloom as knowledge, comprehension, application, analysis, synthesis, and evaluation. We have also introduced the outcomes of globalization, leadership, professional and ethical responsibility, and teamwork as being specifically addressed in this paper. Table 1 provides a comparison of these outcomes and their specified (or assumed) level of attainment as specified by ABET, BOK2 and our new course.

Table 1. Comparison of Outcomes (and Bloom's Level of Attainment) for ABET, BOK2, New Course, and College Incentive. [*] items indicate course outcomes, {*} items are class activities

Outcome	ABET	BOK2	New Course	College Incentive
Globalization	<u>Knowledge</u> Knowledge of contemporary <u>Comprehension</u> Understand … global context	<u>Application</u>	<u>Comprehension</u> Understand cultural factors [9] Understand … globalization [10] <u>Application</u> Commit to act … global community [8] Practice critical and creative thinking skills for evaluation {Taking Sides Project}	
Leadership	<u>Comprehension</u> Explain	<u>Application</u>	<u>Comprehension</u> Understand … Leadership, introduced to theories [1] <u>Application</u> Strive to develop leadership characteristics [2]	<u>Knowledge</u> Frosh - Be Familiar <u>Comprehension</u> Soph - Understand <u>Application</u> Jr - Apply Principles <u>Analysis</u> Sr - Apply Principles
Professional and Ethical Responsibility	<u>Comprehension</u> Understanding of professional and ethical responsibility	<u>Analysis</u>	<u>Comprehension</u> Understand … code of ethics [6] <u>Application</u> Commit to practice … code of ethics [6] Practice critical and creative thinking skills for evaluation {Small Helm Project} <u>Analysis</u> Use structured resolution approach for analysis and evaluation {case studies}	
Teamwork	<u>Application</u> Ability to function on multidiciplinary teams	<u>Application</u>	<u>Application</u> Demonstrate … team skills [5]	

In addition to the leadership focus of the class we are describing, our college has an additional incentive on Leadership. Leadership is conceptualized as the intersection of three components: (1) personal characteristics and development; (2) global and cultural perspective; and (3) a functional context in which leadership is practiced. The three concepts are each supported in the new course by instruction, reading, discussion and project work. Outside of the course, the leadership concepts are presented in a sequence of college- and department-based activities that ascend through the Bloom levels during the four-year curriculum. First year activities are sponsored by the College and focus on presenting the message of leadership at orientation meetings and colloquia. The sophomore emphasis focuses on our new course, while individual units are creating their own activities for the junior and senior years. An emphasis on leadership in teams and projects is most commonly adopted by college units for their portion of implementing leadership concepts.

Course modules that address BOK2 outcomes

The course is made up of three separate but related topic areas, all of which support each other and have a foundation of engineering and technology. The three topic areas are: moral reasoning, leadership, and global technology issues.

Moral reasoning: In this part of the class, we use fundamental principles to build a foundation and engineering problem solving approach for resolving ethical dilemmas. The procedure involves:

- Studying the dilemma in detail
- Pose alternatives and consider consequences
- Choosing a desired resolution and obtaining confirmation
- Implementing the decision and assess the consequences

That procedure has as its basis the scientific method. As a part of the class, students are given scenarios in which they are required to apply the procedure to resolve the dilemmas.

Leadership: This part of the course builds upon the moral reasoning topic. Students are instructed in teaming issues as well as various leadership theories. They are then exposed to various scenarios in which they need to consider effective leadership practices. Students are also introduced to a 360-leadership assessment tool. As an assignment in the course, the students are asked to conduct a self-assessment of their leadership skills as well as give the instrument to several of their peers, employers, etc.

Global technology issues: This part of the course builds upon the other two topic areas. Students are instructed in the following subjects: the role of technology in society, personal responsibilities, and the common good; water, energy, and other global technology issues; and principles of responsible development and appropriate use of technology. They are also introduced to issues involving international teams that are increasingly being used for technology development. As an example, they may consider a power plant that is being built in the Philippines. The plant is being designed by engineers in Romania, built by engineers and workers from several neighboring countries to the Philippines, and managed by an engineering firm in the United States. In addition, students study the advances in technology that have "flattened" the world, enabling world competition, leveling the availability of information, communications, and competitive opportunities throughout the world. Students are asked to consider such issues as understanding other cultures, valuing their diversity, and the required attributes of successful employees in our modern world as they discuss the wise use and development of technology in the global arena. A culminating experience for this part of the course is a project that involves the students teaming up to conduct an analysis of a pertinent issue in the global technology area. As part of this project, students are required to conduct a survey to identify public literacy regarding their chosen issue and then present a summary report regarding both sides of the issue. Students also use the book Taking Sides – Clashing Views on Global Issues[16]as an important reference for this project.

Student Evaluations of BOK2 modules

As a part of the evaluation of this class, students are asked to rate the individual teaching modules and activities used. They are instructed to rate 34 separate aspects (i.e. 3 in teamwork, 12 in ethics, 7 in leadership, and 12 in global awareness). A 1-7 point scale was used where 1 = (remove this aspect of the class), 4 = (OK for the class), and 7 = (One of the better subjects of the class). The averages of the rating of each of the aspects of the course in one of the sections of the class for Fall 2009 were:

Teamwork = 5.25
Ethics = 5.30
Leadership = 5.33
Globalization = 4.76

Even though the globalization aspect of the class received a lower rating than the other aspects, it was still given a positive rating by the students. Perhaps the lower rating was due to the fact that it was the last section of the class. An unexpected aspect of this evaluation was that higher individual ratings were given to class components that focused on readings from experts in the field followed by class discussion compared to class components that had video presentations of case studies followed by class discussion.

Efforts to prepare the requisite faculty to teach this course.

During the first few semesters of piloting the course, the classes were taught by the professor who designed it. As the demand grew, two additional colleagues were asked to teach sections. Now that the college initiatives have led to all units either encouraging or requiring students to take the course, more sections have been added. This has led to several college faculty from various departments to be assigned to teach the course. Having faculty from different engineering and technology disciplines, all teaching a course that must have a certain element of common content, provides several challenges. To aid in minimizing these challenges, a type of professional development for assigned and interested faculty has been conducted. Resources and teaching modules have been compiled and made available to each of the new teachers of the course. Several college faculty, including the designer of the course, met for several weeks and discussed each aspect of the course during the summer of 2009. The faculty members that taught the course for the first time last semester had ready access to the designer of the course during the semester. Those teachers will be used in professional development activities for new teachers the coming semester and then the cycle will repeat itself next year.

The overall challenge, of course, is to maintain the requirements that the college leadership has formulated relative to college initiatives, to maintain the requirements for ABET accreditation, and to maintain the requirements for the course to continue to meet university's general education approval and still allow the individual faculty members' freedom to include their own teaching styles and content that they desire to emphasize.

Potential embedded indicators for ABET assessment

Proper assessment of all ABET outcomes are required to achieve accreditation. Embedded indicators provide a method for assessment from specific evaluations of student performance in an activity such as an exam, project, or assignment that correlates directly to a specific outcome. Embedded indicators are generally normal graded assignments that are used in a class and consequently no new instrument needs to be created for assessment.[17] Such assessments, as shown by Bower and Davis[18] can also be used in conjunction with the six levels Bloom's Taxonomy.

In the course we are teaching, the following embedded indicators could be considered for ABET outcomes assessment. Potential embedded indicators for Bloom's level 2 (Comprehension), level 3 (Application), and level 4 (Analysis) are given.

Globalization:

Level 2 – Comprehension determined from an exam question that requires students to explain a concept of globalization. For example, "Thomas Freidman called his book, The World is Flat. What did he mean by that and where do you agree and where do you disagree with him."

Level 3 – Application evaluated from graded participation on the Small Helm and/or the Taking Sides Project. The Small Helm project is a study and report of the graft and corruption that is prevalent in the engineering/technology community in a specific country. Completion of this project requires a recommend remedy that could reduce this problem. The Taking Sides project is another team effort that involves researching a current global controversy and reporting the facts of the opposing sides of the issue.

Leadership:

Level 2 – Comprehension determined from an exam question requiring the student to explain a concept of leadership. For example, "Considering Collin's book, Good to Great, What are the two qualities that a level 5 leader must blend?"

Level 3 – Application evaluated from a major writing assignment wherein a personal leadership theory is developed and explained. Application from a professional 360 instrument, that requires the assessment of personal leadership traits by peers is completed and graded.

Professional and Ethical Responsibility:

Level 2 – Comprehension determined from an exam question requiring the student to explain a concept of professional and ethical responsibility. For example, "Identify the Professional Code of Ethics you studied for this class and list 4 important components of that code."

Level 3 – Application evaluated from an exam question that presents an engineering ethical dilemma case and requires a thoughtful resolution for the situation.

Level 4 – Analysis measured by graded response to written student resolutions of ethical case studies. The student written resolution must indicate the elements and reasoning of the structured approach used for resolving the case.

Teamwork:

Level 2 – Comprehension determined from an exam question requiring the student to explain a concept of teamwork. For example, "Considering the reading and discussion in class, List 4 of the 5 'Dysfunctions of a team'."

Level 3 – Application from evaluation by other members of team of the student's participation in "Small Helm" and "Taking Sides" team projects. See rubric in appendix that facilitates this evaluation.

Summary

Global awareness, leadership, professional and ethical responsibility, and teamwork are academic outcomes that are being promoted by the National Academy of Engineering, the American Society of Engineers, ABET, various popular advocates, as well as the administration of our college. However, engineering and technology curricula are already full and have little room for including additional material or adding new required courses. To address this issue, we have developed, and had approved, a new general education course, taught within the college of engineering and technology, that covers these subjects in an effective manner. There is no additional credit requirement for engineering or technology students to take this class because it fills existing general education requirements.

The new class has been in the curriculum since Fall semester, 2008. All of the academic programs within the college are now either recommending or requiring the course for their students. Currently two large sections (i.e. 70 students/section) are offered each semester and additional sections are projected for the future. Many of the elements of the course could be adopted directly as embedded indicators for ABET assessment tools. The level of the outcome specified in the new class in the areas of leadership, professional and ethical responsibility, and teamwork meets the level suggested in ASCE's BOK2. When coupled with the total college incentives, the level of the leadership outcome surpasses BOK2's requirements.

The topics of this course naturally lead to a great deal of student discussion. The typical section size of 70 students obviously presents challenges to provide the opportunity for an adequate number of students to actively participate. To address this issue, as many of the topics are introduced, students are asked to join in discussion with their near neighbors to consider the topic. In addition, several times during the semester the teams (i.e. 4-6 students) are asked to sit together and discuss the topics introduced and resolve the dilemmas defined, amongst themselves. At the beginning of the course, a specific point is made that a portion of the final grade will be based on verbal course participation and the grade will be negatively impacted by students who either "over" or "under" participate.

The students who take the course have given it very good student ratings. These evaluations suggest the course is well received and meeting students' interest in these important areas of content and student development.

APPENDIX

Teammate Participation Rubric Small Helm

Team ________________

Teammate Evaluated ________________

My Name ________________

	Evaluating Teammates				
	1	**2**	**3**	**4**	**Total**
Helping	The teammate never offered assistance to other teammates.	The teammate sometime offered assistance to other teammates.	The teammate offered assistance to each other most of the time.	The teammate always offered assistance to other teammates.	
Listening	The teammate never worked from others' ideas	The teammate sometimes worked from others' ideas	The teammate worked form others' ideas most of the time.	The teammate always worked from others' ideas	
Participating	The teammate never contributed to the project	The teammate sometimes contributed to the project	The teammate contributed to the project most of the time	The teammate always contributed to the project	
Persuading	The teammate never exchanged, defended and rethought ideas.	The teammate sometimes exchanged, defended and rethought ideas.	The teammate exchanged, defended, and rethought ideas most of the time	The teammate always exchanged, defended and rethought ideas.	
Questioning	The teammate never interacted, discussed, or posed questions to other team members	The teammate sometimes interacted, discussed, or posed questions to other team members	The teammate interacted, discussed, or posed questions to other team members most of the time	The teammate always interacted, discussed, or posed questions to other team members	
Respecting	The teammate never encouraged and supported the ideas and efforts of others	The teammate sometimes encouraged and supported the ideas and efforts of others	The teammate encouraged and supported the ideas and efforts of others most of the time	The teammate always encouraged and supported the ideas and efforts of others	
Sharing	The teammate never offered ideas or reported his/her findings to others	The teammate sometimes offered ideas or reported his/her findings to others	The teammate offered ideas or reported his/her findings to others most of the time	The teammate always offered ideas or reported his/her findings to others	
				Total Points:	

The following form is to be submitted by each student on the final day of Small Helm Presentations

Teammate Participation Rubric for Small Helm Project

Team Member	Helping	Listening	Participating	Persuading	Questioning	Respecting	Sharing	Total
1								
2								
3								
4								
5								

Submitted By ______________________________

I am a member of team ______________________________

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