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Instructor's Guide for
Societal Impact Module

Harold P.E. Stern

"Engineers should obtain a broad education necessary to understand the impact of engineering solutions in a global, societal, and environmental context consistent with the principles of sustainable development"

INTRODUCTION

This module is designed to heighten students' awareness of the global, societal, and environmental impact of the solutions which they, as engineers, will design and implement in their careers. Key responsibilities are emphasized, including the responsibility to anticipate consequences of their actions, to inform society of the impact of their proposed solutions, and to ensure that society gives input and approval before a solution is implemented. Procedures are developed to ensure that engineers will exercise these responsibilities, and case studies are researched and analyzed by the students and presented to the class.

JUSTIFICATION

Engineering is an applied science. Engineers apply knowledge of mathematics and natural sciences to solve problems and develop devices and systems for the benefit of mankind [1]. Since our mission is to help mankind, our activities have significant social, environmental, and global impact. Engineers must therefore be capable of understanding the impact of engineering solutions in a global, societal, and environmental context consistent with the principles of sustainable development.

STUDENT ACTIVITIES:

Student activities within this module are as follows:

1. Develop a series of specific examples where engineering solutions have had a broad global, societal, and environmental impact.
2. Develop a procedure to minimize unintended consequences of engineering solutions.
3. Perform an in-depth study of a real-world engineering solution and its positive and negative, intended and unintended consequences. Analyze the solution to see if the negative consequences could have been further reduced and if it would have been possible to anticipate the unintended consequences.
4. Present the case study performed in item #3 above.

OBJECTIVES:

Graduates should be able to:

a) Identify global, societal, and environmental implications of various technological issues within their engineering discipline.
b) Create a comprehensive list of questions concerning global, societal, and environmental impact of a **particular** engineering implementation within their engineering discipline.

c) Identify fora (journals, websites, newspapers, etc.) where global, societal, and environmental issues of engineering are discussed.
d) Find websites or other public domain material concerning global, societal, and environmental impact of a **specific** engineering solution within their discipline.
e) Prepare an oral or written report concerning global, societal, and environmental impact of a **specific** engineering implementation within their discipline.
f) Identify appropriate governmental regulatory bodies and appropriate general regulations concerning global, societal, and environmental impact of engineering within their specific discipline.

PREREQUISITE KNOWLEDGE OR SKILLS:

The only prerequisite knowledge for this module is that students know how to access pages from the World Wide Web. Knowledge of Powerpoint will also be useful, as students will be making presentations in Class #3, but such knowledge is not required.

CLASSROOM REQUIREMENTS:

1) A computer with Powerpoint and an overhead projector capable of displaying the computer's screen.
2) A large blackboard or whiteboard for the instructor to organize student responses to questions. This blackboard is especially needed for Class #2. I do not believe that an overhead projector or computer with overhead projection capability is a good substitute for a large blackboard, since the blackboard can simultaneously display considerably more material.

CLASSES:

Class #1

This first class is to make students aware of the need to consider the societal impact of their work. The students will develop specific examples and be introduced to the Law of Unintended Consequences. As homework for the next class, students will be asked to develop a set of procedures to help ensure that unintended consequences to engineering solutions will be as few and as minimal as possible, that society is informed of the tradeoffs involved in an engineering solution, and that society gives approval before the solution is implemented.

Advance work for instructor:

At least one class in advance, form student groups with 3 - 4 students each. Either form the groups yourself or let the students form them. Create groups to exhibit as much diversity as possible, but do not isolate an individual member of a minority or underrepresented group.

In-Class:

A. Discuss the responsibilities of an engineer and how an engineer's work can impact society. [Use slides 1 - 5 of the Class #1 Powerpoint presentation, which is attached along with speaker's notes.] (10 min)

B. Group Assignment #1 [Use slide 6 of the Class #1 Powerpoint presentation, which is attached along with speaker's notes.] (15 min)

This assignment, shown on Powerpoint slide 6, reads as follows:

Provide three (3) real-world examples of proposed engineering solutions which have had a significant impact on society. Briefly discuss the original problem which inspired each proposed solution and the positive and negative impacts of each of the solutions. You cannot use the specific examples which the instructor has just discussed.

Be sure to mention that each group needs to write down its examples and the highlights of its discussions concerning the original problem and the positive and negative impacts of the proposed solution. This written list will be turned in by each group at the end of class.

C. Ask groups to read their examples out loud [Use slide 7 of the Class #1 Powerpoint presentation, which is attached along with speaker's notes.] (10 min)

Write the examples on the Powerpoint slide. There will, of course, be duplication. *Keep mental track of the duplicate examples but list them only once*. (10 min.)

D. Provide the case study of Kudzu and soil erosion [Use slides 8-13 of the Class #1 Powerpoint presentation, which is attached along with speaker's notes.] Stress the Law of Unintended Consequences (Powerpoint slide 12). (15 min.)

This case study illustrates that some of the negative societal impacts of an engineering solution may not be anticipated by engineers or by society before the solution is implemented. I've called this concept the Law of Unintended Consequences, which I state as "No matter how good a solution is, there will be some unintended side effects" [2]. This concept will be a key motivation in studying the impact of engineering solutions in a global, societal, and environmental context.

F. Group Assignment #2 [Given in Slide 14 of the Class #1 Powerpoint presentation, which is attached along with speaker's notes.] This will be homework and must be completed before the next class.

This assignment, shown on Powerpoint slide 14, reads as follows:

Before the next class, develop a set of specific procedures which practicing engineers can use to ensure, as best as possible, that unintended consequences are limited, that society is informed of the tradeoffs involved in an engineering solution, and that society gives approval before the solution is implemented.

NOTE: Make a copy of your list for your group to keep and use. You will turn in the original to the instructor at the end of next class.

G. Collect Group Assignment #1

Class #2

This second class is designed to develop, through a class-wide consensus, a set of procedures to help ensure that unintended consequences to engineering solutions will be as few and as minimal as possible, to obtain input from society at large, and to ensure that society is fully informed of the consequences of an engineering solution and gives its consent and approval. Certain key elements must be included (see section B below). Students will also learn how to find resources to help them follow the procedures.

Advance work for instructor:

1) Grade Group Assignment #1
   Rubrics: Grade easily, but make sure that the three examples are sufficiently different and that the students have listed a reasonable number of positive and negative effects for each example. Make sure that the students understand that this is not a 3-class B.S. session, but that you want them to *think*.
2) Assign a unique example to each group for Group Assignment #3 (see below).
   In Class #3 each group will present and analyze a case of a real-world engineering solution (this assignment will be described in more detail in the in-class notes below). Assign each group a case from their list in Group Assignment #1, making sure that each group gets to present one of the examples it chose, but also that each group is presenting a different case.

In-Class:

A. Discussion - Establishment of procedures to minimize unintended consequences and to gain societal input and consent.

Part I **[Use slides 1 - 5 of the Class #2 Powerpoint presentation, which is attached along with speaker's notes.] (20 min)**

Ask groups to discuss the procedures they developed as Group Assignment #2 (assigned at the end of Class #1). As the discussion commences, use the blackboard or whiteboard to record the key steps suggested by the groups. I suggest using a blackboard or whiteboard instead of Powerpoint to record the responses, since there will be many responses and they should all be displayed simultaneously (this will help students to group similar responses). Key steps in the procedure should include at least the following (these steps are itemized on Powerpoint slides 4 and 5):

i) Study similar problems, previous solutions, and their societal impact.
ii) Identify technological trends associated with the proposed solution and project possible societal impact of these trends so that unintended consequences can be anticipated.
iii) Research any laws and regulations which may exist concerning a proposed solution.
iv) Determine appropriate ways to inform society and solicit an informed consensus.

Once input has been solicited from the groups, ensure that the appropriate steps are written on the blackboard (if any of the above steps are not suggested by a group, you need to suggest them). If you and the group develop any additional steps, you also need to list them.

Part II **[Use slides 6 - 10 of the Class #2 Powerpoint presentation, which is attached along with speaker's notes.] (20 min)**

Now ask students if they know where they can find resources to help them with the above steps. Take suggestions from class (type the suggestions onto Powerpoint slides 7, 8, 9, and 10) and offer your own suggestions (see speaker's notes on slides 7 - 10 for suggestions). Type carefully, because you may wish to hand out copies of slides 7 - 10 AFTER the class discussion to assist the students with their Class 3 presentation.

C. Collect Group Assignment #2 (note that students have been asked to make a copy for their own use). Print out and distribute copies of Powerpoint slides 7 - 10.

D. Group Assignment #3 [Given in slide 11 of the Class #2 Powerpoint presentation, which is attached along with speaker's notes.] This will be homework and must be completed before the next class.

This assignment, shown on Powerpoint slide 11, reads as follows:

Your instructor has selected one example from each group's Group Exercise #1. In the next class, each group will make a 15-minute presentation concerning their assigned example discussing its positive and negative, intended and unintended consequences. The group and audience will also be asked to "second guess" and discuss what they would have done to anticipate unintended consequences and to "improve" the solutions.

In Group Assignment #1, the groups were asked to list 3 real-world examples of engineering solutions which have had a significant impact on society. Now return Group Assignment #1 (graded), circling the example you have selected for each group. You may wish to hand out a guideline to help students prepare their presentation. This gudeline should contain Powerpoint slides 7 - 10 from this class (with class contributions typed in) and should also contain a summary of the rubrics which will be used to grade the presentation (suggested rubrics are given in the Class #3 notes below).

Class #3

This third class is designed to allow students to study real-world examples of engineering solutions and to analyze their consequences. Students will identify positive and negative, intended and unintended consequences and will also be asked to "second guess" and discuss what they would have done to anticipate unintended consequences and to "improve" the solutions.

Advance work for instructor:

1) Grade Group Assignment #2

Rubrics: Grade according to effort and according to the number of key points from Class #2 which are included (see list of key points in Class 2 Part I notes above).

In-Class:

A. Group Presentations

Presentations will require at least 15 minutes each and should each conclude with a question and answer session.

Rubrics for grading presentations:

a) Was presentation smooth, practiced, and professional?
b) Did students present both positive and negative consequences?
c) Did students discuss any unintended consequences?
d) Did students provide sufficient analysis and include some original suggestions?

B. Summary

Summarize the material from the last three classes. Particular thoughts could include:

a) The significance of an engineer's work, how it can impact society, and the consequent responsibility of the engineer to analyze the societal impact of potential solutions.
b) The law of unintended consequences is very real.
c) Unintended consequences and their impact can be minimized by following a set of procedures similar to the one outlined in class #2.

Additional Assignments:

Objective (b), "*create a comprehensive list of questions concerning global, societal, and environmental impact of a **particular** engineering implementation within the student's engineering discipline*", is not tested within this 3-class course as outlined above. This objective could be tested with a group homework assignment following the third class. I leave this to the instructor's discretion, as she/he may feel that, coupled with the other assignments, this last homework assignment would make the module's workload excessive for the students.

END NOTES:

[1] This has been paraphrased from the ABET web site.
[2] The Law of Unintended Consequences was developed in a political context by Molly Ivins, syndicated columnist for the Fort Worth Star-Telegram.

SOURCES:

1) http://www4.ncsu.edu/unity/users/j/jherkert/ - Web page for the IEEE Society on Social Implications of Technology
2) *IEEE Technology and Society Magazine*, available in Rodgers library. The current issue (and other information) is also available on-line at http://www.njcc.com/~techsoc/
3) Present and past year's proceedings from the annual International Symposium on Technology and Society. Some of this information is also available on-line at http://www4.ncsu.edu/unity/users/j/jherkert/istas.html
4) *Social, Ethical, and Policy Implications of Engineering, Selected Readings*, by Joseph R. Herkert; IEEE Press. I have a copy of this book.
5) EPA home web page http://www.epa.gov
6) EPA regulations page http://www.epa.gov/epahome/lawreg.htm
7) OSHA home web page http://www.osha.gpv
8) EPA regulations page http://www.osha.gov/comp-links.html

9) United States Code of Federal Regulations (CFR). Online access at http://www.access.gpo.gov/nara/cfr/index.html