Teaching Moral Reasoning Skills Within Standard Civil Engineering Courses

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Abstract

This paper guides civil engineering educators in identifying ways in which moral reasoning skills, keyed to current engineering ethics codes, can be effectively taught within standard undergraduate civil engineering courses. Practical suggestions and examples are offered. Particular attention is given to incorporating these concepts within problem solving methodology.

I. Introduction

The average workday of a civil engineer requires the use of "soft skills" (non-technical skills)[9]. Many students will assume managerial duties early (10 years or less) into their career[1]. Many situations in professional life (in the both management and technical aspects) require the application of ethical principles.

According to the Accreditation Board for Engineering and Technology (ABET), criteria for engineering programs in the United States must introduce students to the ethical, social, economic, and safety issues that arise from the practice of engineering. Newly proposed ABET criteria for the 21st century state that programs must demonstrate that their graduates have an understanding of professional and ethical responsibility, an ability to effectively communicate, the broad education necessary to understand the impact of engineering solutions in a global societal context, and a knowledge of contemporary issues[3]. In the past, required courses such as Introduction to Engineering or Professional Issues in Civil Engineering typically included instruction in ethics issues.

In Florida, there is pressure from the state legislature to reduce the number of credit hours required for graduation[4]. This places courses that introduce student engineers to societal issues, ethics, and the role of the engineer in jeopardy because they are neither required nor counted for graduation. The alternative is to teach ethical principles within the context of required technical courses—in effect, "seizing the opportunity" to introduce ethics in a new and very relevant way.

This paper offers suggestions for teaching ethical concepts within several standard civil engineering courses.

II. Development of Moral Reasoning Skills

Studies at Texas A&M University by Self[7] have shown that the effectiveness of teaching ethical issues in engineering is measurable, objective, and quantifiable. A study at Texas A&M conducted in fall 1995/spring 1996 indicated that the intervention of teaching a professional ethics course significantly increases moral reasoning skills of students. This paper proposes that similar positive results can be achieved by teaching ethics principles as part of standard required engineering courses.

Self[7] reviews Kohlberg's three relative levels of morality development, as follows:

Level One, *Pre-conventional Morality*

a. Authority says: "do it" to avoid punishment.
b. Egoistic—"what's in it for me, you scratch my back I'll scratch yours" approach.

Level Two, *Conventional Morality*

a. What is right is what people close and important to you expect. This is an altruistic orientation favoring (in order of importance) children, family, (colleagues, schoolmates), school, college, city, state, country. Sometimes this means favoring one's in-group, colleagues, and people most often associated with or people with like training.
b. Requires societal maintenance and conscience orientation in which one fulfills one's agreed-upon duties and contributes to the welfare of the whole group, institution, or society. Right is defined in terms of that which maintains a smoothly running society and avoids the breakdown of the system.

Level Three, *Post-Conventional (Principled) Morality*

a. Emphasizes individual rights such as life, liberty, but endorses a social contract that protects all peoples' rights with a contractual commitment freely entered upon—i.e. greatest good for greatest number, the best welfare for all humankind.
b. Universal ethical principles of justice, equality, autonomy, and respect for the dignity of all human beings as individual persons. Although laws and social agreements are usually based on these principles, when laws violate these principles, one acts in accordance with the principles. Right is whatever is required by a personal commitment to these universal ethical principles of justice, equality, autonomy, and respect for the dignity of all persons.

Level Three, *Post-Conventional* or *Principled Morality* is clearly justice-based, with the principle of justice considered the highest form of morality. From this perspective, then, moral development and moral reasoning are justice development and justice reasoning[7]. The development of moral reasoning skills can complement the predominant technical reasoning skills of the engineering course. To convey a sense of relevance to our students, elements of moral reasoning should be taught as much as possible—even if, like salt seasoning, it is "sprinkled" here and there, on technical courses.

Historically, in the United States, many moral and ethical codes are traceable to Judeo-Christian precepts of justice, equality, and love for one's fellow man. With love itself, ideally being the pre-eminent motivator for ethical and moral human behavior. Engineering codes emphasize concern for safety, health, and welfare of the public as the primary duty of engineers and so demonstrate Level Three morality. The codes also forbid practices such as allowing conflicts of interest and accepting bribes that would lead to dishonest or unfair treatment of employers' clients or third parties. Some codes explicitly require engineers to treat others fairly.

III. Applicability of Engineering Codes of Ethics

Most civil engineers should be familiar with the American Society of Civil Engineers (ASCE) and National Society of Professional Engineers (NSPE) codes of ethics and canons. It is logical and reasonable that these codes/canons should be considered the guiding standard for evaluation of most ethical issues in civil engineering practice. It is recommended that they constitute the fundamental model used by students and professors to evaluate ethical questions in civil engineering. In the sections that follow, we shall examine teachable ethics topics and their adaptations to technical courses.

IV. Teachable Topics Relevant to Ethics in Civil Engineering

Below are examples of teachable core topics that cover most ethical issues that will be encountered in civil engineering practice:

(a) The ASCE and NSPE Codes of Ethics are binding upon ASCE and NSPE members. They are examples of codification of ethical behavior.
(b) Health, safety, and welfare of the public are the paramount concerns.
(c) Serving employers and clients with fidelity (as long as that loyalty does not lead to compromising the safety, health, property, or welfare of the public).
(d) Avoiding conflict of interest.
(e) Maintaining honor, dignity, and integrity of the engineer and the engineering profession.
(f) The choice of one's job is a matter of personal and professional ethics.
(g) At times, professional integrity and corporate loyalty may come into conflict.

Students should be required to read both codes at the beginning of the course and be advised that part of their grade will depend on how well they respond to ethical questions embedded within technical problems. Since we are striving for development of moral reasoning skills, the method of teaching should involve scenarios based on documented case studies, if possible.

V. Sources on the Internet

In the mid-1990's, there has been an explosion of web sites for all sort of business, agencies, and organizations. A brief sweep of the World Wide Web alone yields several listings for engineering ethics-related sites. In addition many textbooks are available, both in professional ethics and, specifically, engineering ethics[2]. For example, *The Ethics Center for Engineering & Science* on the World Wide Web maintains an excellent collection of case studies, slide presentations, and essays on the subject of engineering ethics, which could be a valuable source of course material[10].

Good starting points for URL sites that contain instructional resources for ethics are:

National Society of Professional Engineers (NSPE) http://www.nspe.org/eh-home.htm
Texas Tech Engineering Ethics Site http://murdough.ttu.edu/
Ethics Center for Engineering & Science http://ethics.cwru.edu/

These sites link to other useful sites.

VI. Adaptations of Teachable Topics to Technical Courses

We will now look at ways that ethical principles can be applied within actual technical courses in the undergraduate civil engineering curriculum. Most of the examples cited reflect the author's own experience in public works engineering practice.

VII. Computer and Numerical Methods

In this example, incorrect output values that are not fully explained on a homework cover sheet results in a significant point reduction. If the student discusses the error and explains attempts to correct it, few (if any) points are deducted. Encouraged to admit their errors and outline potential remedies, students are able to find and correct their mistakes[5].

To reinforce the importance of ethical and social considerations in engineering practice, at least once in the semester the professor deliberately introduces an error into a homework assignment. To receive full credit the student must detect the error, correct it, implement the correction, and discuss it on the homework cover sheet. This promotes critical thinking and students learn to trust themselves and the solution methods proved in class. They learn another lesson: Textbooks may contain errors and instructors may make mistakes, but the engineer cannot allow the errors of others to affect an engineering analysis[5].

VIII. Structural Analysis and Design

The example cited above under Computer and Numerical Methods would also fit nicely for structural analysis or design assignments. The output values in this case could be the final design sketch of a steel or concrete member, with supporting design assumptions.

Another example concerns responding to a Request for Proposal (RFP) by a structural engineering consultant. The RFP asks for a response from bidders concerning the cost-effectiveness of a particular bowstring truss roof system. The engineer has experienced problems with this particular roof system due to its propensity to leak. On a previous project, this system turned out to be an economic failure for the owner, but the engineer learned many valuable lessons from this experience. Furnish a proper response to the RFP.

This example should teach that truthfulness and disclosure is expected of an engineer. It will also teach that if the engineer has reason to believe the owner's contemplated project will not succeed, it is desirable to point out the corrective measures that could be taken to preclude recurrence of the problem. It could be pointed out that since this is a proposal and the engineer must represent himself in a positive light in order to compete for the job, the description of the failure does not need to be overly cumbersome, as it will detract from the positive aspects of the engineer's capabilities[8] and the value to the owner of the engineer's "lessons-learned" on another project.

IX. Soil Mechanics and Foundations

Students are instructed to treat the submission of a retaining wall design assignment as a design/build project proposal. Proposers must design the wall in accordance with specified agency guidelines. One of the agency guidelines prohibits certain types of proprietary retaining wall products when used in a corrosive soil environment. The student engineer is designing and submitting prices for his/her company's proprietary wall system. A last minute addendum to the design criteria package provides geotechnical data to proposers, which indicates that in-situ soils have tested corrosive. This new data effectively renders the engineer's current design unacceptable.

The owner's project manager is a non-engineer and is under extreme pressure from the sponsoring agency to make the project come within budget. He is either unaware of, or ignores the agency guideline on corrosive soils and verbally encourages you to submit a proposal using your current wall system. Historically, your system has fared very well in bids because of its relative economy. If submitted, your proposal would probably win over other systems.

Should you, the engineer, bid the wall system using your current product? If you decide to bid the project, how would you modify your design to make it acceptable under current guidelines for corrosive soils?

This exercise teaches engineers that they should hold paramount the lives, safety, and welfare of the public and should approve only design documents which are in conformity with accepted engineering standards.

X. Transportation Engineering

The consulting engineer submitted final roadway plans and specifications for a highway project to the agency's project manager, for bidding purposes. The project manager accepted the work and prepared to bid the project. In the meantime, the consulting engineer, confident that she completed all the requirements of the design contract with the agency, submits her final invoice. The project manager agrees that the design is complete, and authorizes final payment to the consulting engineer for services rendered. After successful bidding and award of the project, the consulting engineer attends a State DOT-sponsored roadside design seminar and learns that she has improperly designed critical roadside geometric features (i.e. center median, roadside guardrail) at bridge approaches. If the current geometric design is constructed, there is a strong potential for head-on collision on the bridge. Is the engineer required to bring this to the attention of the project manager and then correct the design at the firm's expense? After all, the project manager accepted the original design, the final invoice was paid, and the firm's principals will “hit the ceiling” if any more non-billable time is spent redesigning a “completed” project.

How should the engineer respond to this situation? How would you re-design the roadside features to meet applicable standards and state the reasons why the current design is deficient?

This exercise again teaches the fundamental principle of holding the health, safety, and welfare of the public in highest standing, the admission of one’s errors, and of informing the owner when a project will not be successful. Perhaps the class could also discuss ways to effectively and honestly deal with the principals of the design firm in such cases.

XI. Conclusions and Recommendations

Moral reasoning through observance of ethical codes is as important to good engineering practice as mathematics, physics, design subjects, etc. With some imagination and planning, instructors can incorporate ethical considerations into technical course work. It is the responsibility of all engineering instructors to teach more than textbook-based course material when the opportunity presents itself. This should be taken a step further by the assertion that the instructor should seize such teaching opportunities through careful design of course material and assignments. It takes more of the instructor’s time to accomplish these goals, but the results are well worth the effort. Maintaining the supply of technically grounded as well as ethically grounded engineers is an inestimable benefit to society and the engineering profession. Our graduates will be better prepared to effectively deal with ethical questions in the real world of civil engineering practice.

Instructors are encouraged to search for ethics examples in practice that will lend themselves to a teaching opportunity in their field. Networking and remaining conversant with practicing engineers on ethical issues will also enhance the introduction of practical ethics problems into assignments. This will require creativity to develop and incorporate into a technical course. Perhaps this paper has sparked educators’ interest in enhancing and upgrading their technical course material to include practical engineering ethics.

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