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INTEGRATING ETHICS INTO ENGINEERING DESIGN OF CONSTRUCTION PROCESS

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ABSTRACT

Increasingly stringent and pervasive government regulations are a fact of life in our society. There are regulations covering business, manufacturing, finance, safety, the environment, education, research, law, medicine, and government itself. The increasingly stringent application of OSHA standards in the construction industry is based on the concern for human life. Equality, life, liberty, the pursuit of happiness, security, civic duty, justice, honor, rule of law, privacy, and private property; these are the widely held values in our society, these are the values we must live by to avoid regulation, and these are the values that should serve as a basis for ethics instruction. There is a lack of focus in the construction field regarding the integration of social impact awareness and ethical behavior into professional practice. The challenge engineering educators face is to develop strategies that will raise the awareness of students regarding ethical issues related to construction at the same time that they are developing their technical expertise.

Education has a special opportunity to train people to live and work in accord with societal values. Construction Courses in the department of Civil and Environmental Engineering at the Pennsylvania State University focus on the planning, organization, monitoring and control of the construction projects. The emphasis of these courses is on engineering design of construction process. The student gains the knowledge necessary to apply engineering principles in analyzing economical approaches to construction project. There is currently a scarcity of information relating to an ethical code for construction professionals.

The purpose of this paper is to discuss the various disciplines that might be available for input and resources available for research and for use in developing course material and classroom presentation. Problem solving in ethics is the skill most needed by students, and most difficult to teach. The approach under consideration at the construction program is to use interactive videodisc and invited guest lectures from construction industry. The course will explore ethical theories, concepts of critical thinking, and major ethical issues related to construction industry. The Leonhard Center for the Enhancement of Engineering Education and Rock Ethics Institute are helping in development of this new program for the teaching and study of applied professional ethics as it relates to the construction education.

1. INTRODUCTION

The preamble to the Code of Ethics for Engineers of the National Society of Professional Engineers states in part: "Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people [3]. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that required adherence to the principles of ethical conduct."

ABET 2000 criterion [1] states that 'Engineering programs must demonstrate that their students have an understanding of professional and ethical responsibility.' What exactly is the challenge that ABET has provided engineering schools in relation to the teaching of ethics? Simply stated, it is to teach students arguments and theories about what actions are right (or wrong), and which states of affairs are good (or bad) related to the professional practice of engineering. A list of what students need to be able to do to satisfy this outcome is as follows:

1. ability to offer and defend a definition of engineering ethics,
2. ability to recall the essential elements of a professional engineering code of conduct,
3. ability to explain multiple reasons for being ethical in the practice of engineering,
4. ability to identify and critically analyze common ethical dilemmas in the practice of engineering, including possible consequences,
5. ability to analyze ethical arguments to discover which argument one has the best reasons to believe and act upon,
6. ability to speak and write in a way that is logical, complete, consistent, and clear, and that can recognize potential objections to one's position,
7. ability to recognize the historical importance to our society of previous ethical decisions made in relation to engineering and technology,
8. ability to recognize actions that expose oneself to legal liability,
9. ability to use basic risk assessment techniques in engineering decision-making,
10. ability to recognize the regional and global consequences of engineering decisions.

This list is based on the belief that there is significant overlap in criteria and thus, they should be considered together. Most construction engineering educators are unsure how to include this element in their curriculum, and even if they do have some idea, are almost certain to not know how to assess whether or not this outcome has been achieved. This challenge is particularly difficult given the traditional mindset of technically trained professionals who view social impact and ethics issues as topics auxiliary to the foundation material in construction engineering. In this paper we suggest a strategy in which the development of an ethical framework is viewed as fundamental to the development of competent construction professionals. Our belief is that presenting these topics in a sufficiently holistic and robust way, contrary to the way that they are now apologetically presented in most curricula, will provide a relevance to the other foundation material that will enhance technical expertise and provide a deeper educational experience for construction engineering students.

2. ENGINEERING DESIGN OF CONSTRUCTION PROCESS

The construction industry of today has been built on the needs of the world's inhabitants to provide shelter, conquer distances, harness energy, create public spaces, protect from natural disasters, and build historical monuments. These basic human needs have not changed over time even though the process and environment in which the 'designer' and 'constructor' operate have become increasingly more complicated. Government regulations, environmental permits, and other bureaucratic controls continue to grow. Projects also continue to get larger and more technical, requiring more specialized people, high-tech equipment, and better control systems. This trend will require that tomorrow's project leaders have technical, business, organizational, ethical, and leadership savvy to complete their construction projects successfully.

Many engineers elect to pursue their careers in construction. They may be graduates of construction engineering, civil engineering, mechanical engineering, or other engineering degree programs who have found excellent opportunities in the engineering and management of the construction process. Many new regulations and specifications (for example, those of OSHA and ACI) require a construction engineer to design certain systems for execution of the construction process. In addition, the design-build process often needs a construction professional within the construction organization to coordinate the work of other professional engineers and architects engaged for project.

Society, through the media and the courts, is demanding high standards of construction professional competence and performance. Construction engineers must be aware of their social responsibilities and prepare themselves to reflect critically on the moral dilemmas they will confront. They must fulfil the resultant moral obligations to the public.

3. EDUCATIONAL STRATEGIES TO MEET THE OUTCOME

Karl Stephan [18], associate professor of Electrical and Computer Engineering at the University of Massachusetts, at Amherst, produced a study that revealed that only about one-third of the nation's engineering schools require all students to take any courses in the ethics of engineering. A recent survey indicates that 80% of engineering graduates attend schools that have no ethics-related course requirements. While 16% of institutions and 7% of graduates do have one or more required courses with ethics-related content, these courses are usually not courses in engineering ethics, but rather courses in philosophy or religion that have no specific engineering ethics component.

Why do so few schools have an engineering-ethics requirement? Significant barriers include faculty indifference, student indifference, and the belief that engineering faculty is not competent to teach ethics [7]. Engineering faculty are most comfortable with quantitative concepts, and often do not believe they are qualified to lead class discussions on ethics. Many engineering faculty do not think that they have the time in an already overcrowded syllabus to introduce discussions on professional ethics, or the time in their own schedules to prepare the necessary material. Koehn's [11] findings from courses at Lamar University suggest that while undergraduate students may lack motivation to study ethics, they do have an interest in the social aspects of engineering that could be used to leverage an interest in ethics.

While these are significant barriers to overcome, there are a number of factors, in addition to the ABET 2000 criteria, working in favor of the expanded teaching of ethics in an engineering context [12]. Case studies are valuable and popular because they are widely available, pre-packaged, easily inserted into courses, and engaging for students and faculty [13]. A key consideration in integrating ethics and social impact into the curriculum is to come to grips with the issue of how best to teach and incorporate ethics topics. Basic ethical values are learned in the formative years of childhood in the home and school. The purpose of specific ethics education, such as construction ethics, should not be to indoctrinate the individual with new values, but to assist individuals "in clarifying and applying their ethical values as they encounter new, complex situations where it may not be obvious how ethical values may apply or where the appropriate application of one of these values may conflict with other ethical values. To properly apply the notion of ethics to construction technology, we must first recognize that technology is not value-free, but value-laden.

4. CURRICULUM MODEL TO MEET THE OUTCOME

How can construction ethics be incorporated into an already tight engineering curriculum? There are five basic approaches that one may take – (1) required course in engineering ethics [4], (2) required course that integrates engineering ethics (microethics) with the social context of engineering (macroethics) [6,16], (3) integration of engineering ethics across the curriculum [17], (4) integrated humanities and social science program that addresses all non-technical ABET 2000 outcomes (e.g., Illinois Institute of Technology) or (5) integrated engineering related community service project and lecture series [5]. Course topics should include basic concepts and methods in ethics, typical professional engineering society code of conduct, introduction to the legal system, construction law, organizational loyalty versus professional rights, risk and the engineering decision-making process, and social responsibility versus legal liability.

Our belief is that ethics cannot be taught; rather what can be taught is a framework for evaluating ethical dilemmas and making decisions. In accepting the premise that technology is value-laden, we stress the need to teach a methodology of explicit ethical analysis in all decision-making related to construction technology. A preliminary core of ethical precepts has been developed by the professional civil engineering societies in the form of ethics codes. In this paper we present a model for encouraging the student to compare and combine personal, legal, societal, and professional ethical models into a decision-making framework. The role of ethics education should be to provide students with at least a minimal theoretical background essential for their understanding of the role that values and ethics play in all decision-making, whether it is technical, economic, political, social, or personal.

Theoretical introduction to ethics is appropriate at the freshman or sophomore level. After the student has acquired a sense of the construction industry and grounding in ethical theory, it is time to address the subject of applied ethics for construction professional. Integration of applied ethics into construction curriculum will be the main focus of this paper. This will be a senior level course in the construction engineering and management program, and it will include the following components:

1. Legal System and Maxims of law
2. Construction Law and Contracts
3. Societal Values and Morality
4. Professional Practices and Employer Obligations
5. Construction Ethics Case Studies

The conceptual model for integration of ethics into construction is shown in Figure 1.

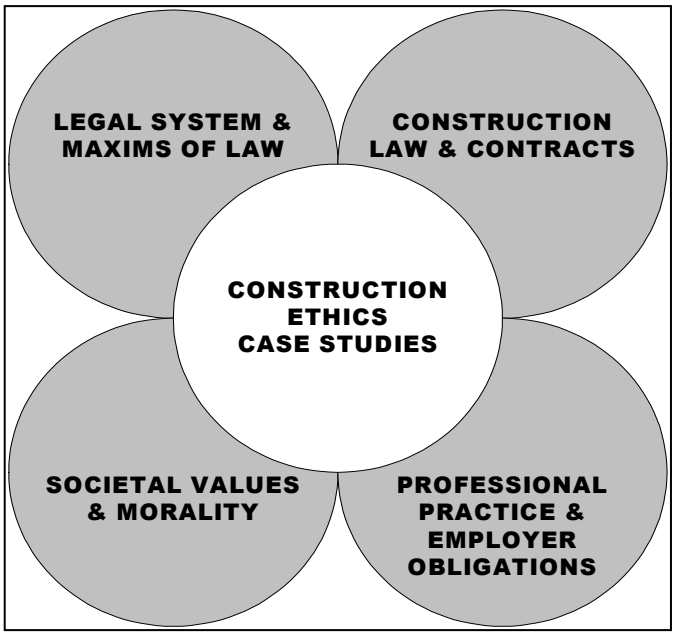

Figure 1. Conceptual Model for Integrating Ethics into Construction Curriculum

4.1. Legal System and Maxims of Law

This section is designed to give students an understanding of how the legal system in the United States operates. This section also gives students the basics that all construction professionals should understand in order to operate effectively in the U.S. market. The word law in the legal sense does not carry the same meaning as in a math or science sense. The word law in math or science means a statement that has been rigorously tested and is considered to be true; however, scientific and mathematical laws are subject to change or modification if new information proves them to be inadequate. Law in legal sense means rules set up by various government agencies to help regulate how people and other entities act and interact [21]. Most laws are subject to change and interpretation.

4.1.1. The Maxims of Law

The maxims of law constitute the basic attitudes of U.S. courts towards legal disputes. The maxims are the underlying principles, often unstated, on which case law is based. Each state, and the federal government, has a constitution that is considered the supreme law of the land. The state and the federal governments are divided into three parts: the executive branch, the legislative branch, and the judicial branch. Most students mistakenly believe that the United States Supreme Court is the supreme court of the land and that all cases can be appealed to it if

the parties have the desire to do so. Rather, only very few cases originating in state courts can be appealed to the United State Supreme Court, namely, cases that involve federal law or an interpretation of the U.S. Constitution. Much of the law regulating the construction industry is state law can never be appealed to the United States Supreme Court. In addition, most cases in the construction industry are resoled by arbitration.

4.1.2. Applying and Using the Law

Merely learning the law is of little or no use, just like learning the rules of baseball but never playing a game. To be useful the rules of baseball must be applied to an actual game. Similarly, the law must be applied to factual situations to be of benefit. Problem solving is commonly used to teach students how to use the law. Seeing how the law is applied to a factual situation and coming to a conclusion makes it is easier to understand how the law works. It is advantageous to this learning process to concentrate on why a specific answer has been chosen. Learning or memorizing an answer because it is 'right' can actually be harmful. A slight change in the facts can easily make a 'right' answer wrong. By understanding why a particular answer is right student will gain skill in applying the law.

4.1.3. Logical Fallacies

Logic is, by definition, the science that evaluates arguments. Arguments may be good, bad, logical, or illogical. Logic is used to evaluate all types of arguments. Arguments can be valid or invalid. Arguments are evaluated for validity through the use of logic – that is, a valid argument is one that is logical. An invalid argument is one that is illogical. The argument is one of the fundamental tools used to apply law. Other fundamental tools include command of language and writing ability.

4.2. Construction Law and Contracts

This section describes the legal rules that govern the design and construction processes. These rules, which are constantly evolving, have three primary sources: Governments develop and adopt statutes and regulations at the federal, state, and local levels; court interpret and enforce statutes and regulations and apply common law principles to resolve disputes; and project participants make many of their own rules by entering into contracts for goods and services. A construction project frequently has many, many people, and legal entities, such as corporations and partnerships, working together in complex contractual and noncontractual relationships [8]. As a general statement, the law allows the parties to determine how they will interact with one another, who will do what, and who will bear the risk for what. These decisions are made by contracts, which are promises or agreements that the law will uphold.

4.2.1. The Role of Government

The federal government may pass statutes that relate to the health, safety, or welfare of citizens or to interstate commerce. Most federal laws apply across the board to many industries and commercial activities and, therefore, affect the construction industry. These include the National Labor Relations Act (NLRA), the Fair Labor Standards Act (FLSA), and the Occupational Safety and Health Act (OSHA) [9]. States have broad powers of regulation and lawmaking. Many state laws, like federal laws, have broad application and affect the construction industry. Mechanics' lien laws are set of state statutes designed to apply specifically to the construction industry. Most states have enacted detailed building codes, either by statutes or regulations.

Local statutes, often called ordinances or by laws, can have a critical impact on all construction projects.

4.2.2. The Role of Courts

Courts are charged with interpreting statutes, regulations, and local ordinances. They also apply common law principles to resolve disputes. Common law is the body of law that has developed over time through the court's interpretation of legal principles. Common law is binding unless and until specifically overruled by the legislature through a statute addressing the particular issue in question. Court systems in the United States are all based on a strict hierarchy. In the federal court system and most state court systems, there are three levels of courts: the trial court, a court of initial appeal (appeals court), and a court of final appeal (Supreme Court).

4.2.3. The Role of Contracts

A contract may be written or oral, but is only formed when there has been an offer to do or provide something that is accepted by another party and is supported by consideration. In addition, each party to the contact must have the capacity to enter into the contract. Because it takes so many individuals and companies to construct a building, and because the design and construction process is complex and imperfect, disputes are common in the construction industry. The court system provides a venue for the resolution of such disputes. Arbitration has long been used as a method of solving disputes, and it has been included in standard construction industry contracts for nearly one hundred years.

4.3. Professional Practice and Employer Obligations

A review of professional codes of ethics will expose students to the existing consensual standards of the construction industry. There is currently a scarcity of information relating to an ethical code for constructional professionals, but the codes of the engineering profession and the American Council of Engineering Consultants will suffice to instill an understanding of the thrust of these standards. Attention may also be given to the opinions of the Board of Ethical Review of the National Society of Professional Engineers, which apply provisions of the code of ethics for Professional Engineers to the ethical problems encountered by engineers.

The nation's (and world's) infrastructure has grown increasingly mature, dense, technically complex, and interconnected, especially in urban areas. To maintain what we have as we plan and build for the future, civil engineers will have to apply creative technologies and solutions. Fortunately, compared with a few decades ago, there are numerous new tools and techniques to address project challenges. All this in an era when the public is playing a more active role on private and public projects alike through a more open planning process, environmental regulations, and elevated community expectations. To be sure, this involvement from end-users and stakeholders provides valuable input, but it adds an element of complexity to the way projects are conceived, planned, designed, and built. Complexity and the difficulties of managing it can contribute to misapplication and unsafe practice. As the complexity in society and projects mounts, the risk to public health, safety and welfare increases. Future civil engineering professionals must demonstrate an understanding of the relationship of engineering to critical contemporary issues. They must demonstrate an appreciation for culture, history, and human behavior, as well as the environment, sustainable design, and public administration. Tomorrow's

civil engineers must understand the facility life-cycle process, asset management, as well as appropriate professional codes, standards, and processes that regulate safe design. They must demonstrate knowledge of the ethical and professional responsibility of the civil engineer to improve the quality of life and contribute to the health, safety, and welfare of the population. They must also develop a commitment to practice according to these professional and ethical standards. As indicated in the ASCE policy [2], "practice of civil engineering at the professional level" means "practice as a licensed professional engineer." Civil engineer should demonstrate an understanding of and a commitment to practice according to the seven Fundamental Canons of Ethics and the associated Guidelines to Practice under the Fundamental Canons of Ethics. A thoughtful and careful weighing of alternatives when values conflict is crucial to the responsible conduct of engineering. The civil engineer is to hold paramount public safety, health, and welfare.

The study of the theory of the ethics is naturally the most general, but in being the most general, it is also necessarily less specific in the details of its application. The study of applied ethics is meant to result in more specific guidelines for use in real-world situations [14]. The study of professional ethics addresses the details of situations and issues that arise specific to some profession, but that might be irrelevant to some other profession. The study of ethics and construction is clearly a study of professional ethics. Professional ethics can be different from general ethics to the extent that professional ethics must take into account:

- Relations between practicing professionals and their clients,
- Relations between the profession and society in general,
- Relations among professionals,
- Relations between employee and employer, and perhaps most importantly,
- Specialized technical details of the profession.

4.3. Societal Values and Morality

The study of the acceptable standards of a society is a component of schooling that is essential in helping students to become contributing, responsible and ethically mature persons [20]. Humans, by their very nature, are moral beings. On a daily basis, it is necessary to confront decisions, choices and judgments that involve degrees of "rightness" and "wrongness" [19].

Universities have a role in providing students with the "tools" necessary to improve their decision-making abilities [15]. The importance of this area of education can be obscured by its complexities. However, the Universities are, inevitably, a source of ethical education. The choice is whether or not it will be an explicit part of curriculum. By providing students with a clearer understanding of community values, the relationships of these to personal values, and the skills necessary for dealing with issues, the school can play a supportive role to other institutions in the community, such as the family, in the ethical education of young people.

The Construction Ethics course is designed to ensure integration of the knowledge of societal values and the development of positive personal values. The aim of the ethics course is to help students to become more thoughtful, to think of the interests of others, and to see the ethical implications in their daily lives. The goal of teaching societal values is to assist young construction engineers in their growth as ethical persons who are able to contribute to the well-

being of all individuals and the community. The primary objective is to develop an understanding of community values. To foster student commitment to common ethical values such as respect, responsibility, fairness/justice, tolerance, honesty, kindness, forgiveness, commitment to democratic ideals, loyalty. It is also an objective of this course is to develop the ability to recognize consequences of making ethical decisions.

The content of the course in this section is divided into three parts: Traditional/Historical; Cultural/Ethnic; and Societal/Community.

Traditional/Historical
Many values are reflected historically through traditions represented by things such as religious teachings, or the lives of historical persons. Examining values from this perspective will provide students with a better understanding of how some values have their basis within the historical or traditional part of our society.

Cultural/Ethnic
Values may be derived from membership in a particular cultural or ethnic group. Students study values from the perspectives of various cultural groups in order to contribute to a better understanding of their own community.

Societal/Community
Within this perspective, students will examine values that appear to be accepted by their community and which may lead to greater understanding of societal values.

4.4. Construction Ethics Case Studies

Case studies will be used to demonstrate examples of problems confronted in construction industry. These case studies again highlight issues, and point toward valid resolutions – often without the aid of a code of ethics or any other formula for determining appropriate behavior.

Example Case Study 1:
The Sunshine Construction Company was awarded a $9.2 million project to build a middle school for the Ellsinore School District. AIA A201 (1987) was used as the general conditions of the contract. The liquidated damages were $3,000 per calendar day. A time extension was unlikely. The project involved considerable amounts of masonry, so Sunshine solicited bids from various masonry subcontractors. The low bidder was HardRock Masonry. Their bid was 7.8% below the next lowest bid. After it was determined that Sunshine was the lowest bidder, Sunshine home office managers pressured HardRock to reduce their bid even further until they were 10.3% the next lowest bid. From the beginning, work on the job progressed slowly for a variety of reasons to the point that when HardRock began, the project was four weeks behind the schedule. HardRock made good progress, and after several months, the project was about 2 weeks behind schedule.

In discussions with the HardRock foreman, the Sunshine project manager learned that the masonry crews were illegal aliens from Mexico. The foreman indicated that their wages were low (by US standards), and that most craftsmen sent money to their families in Mexico who were

very poor. The US wages were their primary means of subsistence. The masons were productive, did high quality work, and caused no disciplinary problems on the job. The Sunshine project manager was faced with a problem. If he contacted the Immigration and Naturalization Service (INS) about the illegal Mexicans, they would be deported. The disruption to the project schedule would be significant, and the Sunshine liquidated damages would amount to approximately $10,000. The home office managers would not be happy at all.

Some relevant contract language from AIA A201 is:

Art. 3.3.1
The Contractor shall be solely responsible for and have control over construction means, methods, techniques . . .

Art. 3.4.2
The Contractor shall not permit the employment of unfit persons . . .

Art. 3.7.2
The Contractor shall comply with and give notices required by laws, ordinances, rules, regulations and lawful orders of public authorities . . .

A careful reading of these and other clauses of the general conditions is appropriate.

Ethical Decision –Making

1.What are the negative consequences to Sunshine if project manager contacts INS?
2.What are the negative consequences to Sunshine if project manager does not contact INS?
3.What are the negative consequences to HardRock if project manager contacts INS?
4.What are the negative consequences to masons if project manager contacts INS?
5.What should the project manager do?

5. IMPLEMENTATION

To date the integration of ethics into civil and environmental engineering at the Penn State University has only been partially implemented in the curriculum. Theoretical introduction to ethics have been introduced in a sophomore/junior level classes. The key course module in the senior level construction engineering and project management class will start with lectures covering legal system, construction contracts, societal values, and professional ethical standards, and continued with class discussions of case studies concerning ethical construction practice. For each of the case studies the following seven panel members will actively participate in the construction engineering and project management classroom discussion.

- Attorney from law firm practicing construction law: For providing legal opinion of the construction business issues.
- Representative from federal, state or local regulatory board: For providing expert ethical opinion on the regulations governing construction practice.
- Representative from Contractor firm: For providing ethical opinion from construction project contractor view point.

- Representative of Owner of the project: For providing ethical issues related with construction project from the owner point of view.
- Representative from Design Firm: For providing ethical issues related with construction project from the designer point of view.
- Representative from the construction project management consultants: For providing ethical issues from the consultant point of view.
- Professor who is in charge of the class: For providing the analysis of the legal, contract, societal, and professional ethical standards.

6. MEASURING THE OUTCOME

Assessment of the engineering ethics criterion should be carried out using appropriately designed and tested student surveys, faculty surveys, employer surveys, and course exams [10]. However, probably the most effective way to demonstrate most of the desired outcomes is through student portfolios that contain samples of student essays analyzing ethical issues with which a practicing construction engineer may be faced. These types of essays provide opportunities to demonstrate how a student applies knowledge of different ethical theories to make a decision on what the right thing to do is in a given construction engineering decision dilemma.

7. CONCLUSION

In this paper we have suggested some techniques for introducing ethical activities into main stream construction engineering and management classes. Ethical/professional issues should be seen in the context of construction professionals practicing their profession. It helps to dispel the perception that such issues are less important or neatly separable from construction engineering. Covering these issues in main stream construction engineering classes firmly establishes links between ethical/social issues and technical content, methods, and practices of the profession. Learning technical skills is only one part of becoming a fully developed professional. To be a world-class professional involves a commitment to a higher level of care for those who will be affected by our products.

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