DEVELOPMENT AND EVALUATION OF A MODEL TO ASSESS ENGINEERING ETHICAL REASONING AND DECISION MAKING

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Submitted to the Graduate Faculty of

Swanson School of Engineering in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Pittsburgh

2009

UNIVERSITY OF PITTSBURGH

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Several ethical decision making models have been developed over the last twenty years. Past research has attempted to evaluate these models by assessing numerous factors potentially linked to the decision process involving ethical issues. Past research studying ethical decision making in organizations has focused on the business perspective and on individual decision making. Little empirical research has focused on teams' ethical decision making in engineering and none (to the author's knowledge) have studied the *process* of ethical decision making by engineers.

For this research two primary models have been adopted: *Jones's Synthesis of Ethical Decision Making* model and the *Harris, Pritchard, and Rabins (HPR) Model* widely used in engineering. These models were combined along with factors cited in the literature to form a proposed *Ethical Decision Making in Engineering Model*. Using this model an experimental study involving both individuals and teams of engineering students solving two ethical dilemmas of different moral intensity was used to: (1) investigate whether engineering student teams make "better" decisions than individual engineering students, (2) evaluate the processes used by the individuals and teams to resolve the dilemmas, (3) and assess variables that potentially affect the quality of the resolution and the quality of the decision process.

From this research, the analysis of the team decision making process and its outcomes has enabled the researcher to identify key factors that play a role in engineering ethical decision making, as well as identify potential improvement areas for engineering ethics education. In

general, students who have had an engineering ethics course perform better (in teams or as individuals) than students who did not have engineering ethics course for an engineering dilemma with moderate moral intensity; and teams outperformed individuals on the Resolution attribute and spent more time on Analysis and Recognition of Dilemma attributes. Further, the derived regression analysis models showed that having had an engineering ethics course, working in teams, work experience, being female, the type of engineering major, and the dilemma's moral intensity are significant predictors of the overall Resolution as measured by the report quality.

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PREFACE

This dissertation is dedicated to my parents Stanislaw Rudnicki and Felicja Rudnicka, for their encouragement, support and understanding through my many decades of education.

Its accomplishment is owed to my loving family: my husband Andrzej and my children Natalia and Radomir.

I am indebted to my advisor and dissertation committee chair, Mary E. Besterfield-Sacre and am thankful for the contributions of committee members Kim LaScola Needy, Rosa L. Pinkus, Larry L. Shuman, and Harvey Wolfe, as well as, Matthew M. Mehalik for his assistance on this dissertation.

1.0 PROBLEM STATEMENT

Engineering decisions, such as engineering design-related decisions, often contain ethical issues. Such problems certainly exist in the workplace and engineers may have to deal with an ethical dilemma at some point during their careers. Although basic character and personality traits are formed by the time students enter college, educators have the responsibility of contributing to the moral development of their students (Bok, 1976). In Gilligan's words, "moral development in the college years thus centers on the shift from moral ideology to ethical responsibility" (Bok, 1976, pp. 8-9). Engineering education is no exception.

The National Society of Professional Engineers (NSPE) and the Accreditation Board for Engineering and Technology (ABET) have certainly endorsed the teaching of ethics in engineering. Criterion 3-f of the ABET engineering criteria asserts that "engineering programs must demonstrate that their students have attained…an understanding of professional and ethical responsibility" (ABET Engineering Accreditation Commission, 2007). Pfatteicher (2001) suggests that demonstrating students "understand ethics" need not (indeed should not) imply that we assess whether or not students "behave ethically," either before or after graduation. Hence, it seems important for engineering educators to document and assess students' knowledge, approaches, or processes to solve ethical dilemmas, but not their actual behavior. Herein lays the basis for this dissertation research: *to evaluate those processes engineering students use both individually and in groups when solving ethical dilemmas.*

Intuitively there is a difference between one's personal ethics and the ethical decisions made by groups or individuals in organizations. In an organizational setting, for example, professional codes of ethics should supersede personal beliefs and possibly (but hopefully not) the organization's policy. Understanding why and how individuals and especially groups make ethical decisions in an engineering context will help to improve the ethical decisions made in an organizational and professional context. Much of the research associated with studying ethical decision making in organizations has focused on the business perspective and on individual decision making, little empirical research has been focused on team based ethical decision making specific to engineering.

Engineering ethics differs from business ethics in the types of ethical problems, the way decisions are made (decision process) and the organizational structure by which they are made (individual versus in groups). Drs. Shuman and Wolfe (personal communication, October 2004) claimed that the great majority of examples in the business literature discuss ethics decision-making that affects the customer/consumer while in engineering decisions ethical in nature are made during the design/production process before the "final stage" of introducing the products to the consumer. Several studies in business ethics show overwhelming support for the importance of managing relationships within the group and the pervasive influence of peers in ethical decision making (Loe, Ferrell, and Mansfield, 2000). Yet, only a few studies have been conducted on teams solving ethical issues: and these studies were conducted from a business ethics perspective. Further, and more importantly, the studies focused on the outcome or final resolution, but did not evaluate the decision making *processes* by which individuals and teams solve ethical dilemmas.

This dissertation aims at studying the process by which ethical decisions are made by individuals and groups of engineering students. In general, when solving ethical dilemmas, what resolutions do groups follow? Is the format different for groups with training in engineering ethics from the groups without such training? What factors potentially lead a group to a low (or high) quality resolution? Do students place emphasis on professional knowledge, science and logic, professional codes of ethics when solving engineering ethical dilemmas or do they utilize their own personal biases and beliefs? Specifically, this dissertation attempts to address the following research questions:

1. Is the quality of ethical decisions made by groups of student engineers better than those made by individuals? Are there differences between individuals and groups of engineering students with respect to the:
    - quality of the resolution?
    - quality of the decision making process?
2. Particular to the process, what aspects (i.e. recognition, gathering information, analysis, perspective, etc.) do teams employ when making an ethical decision and how do they compare or contrast from those made by the individuals? In addition, what are the factors (i.e. level of educational experience, training in ethics, etc.) that play a significant role in the quality of the resolution reached?
3. Complementary to models developed for individuals, can a model for ethical decision making for teams be evaluated and used to help assess engineering students solving ethical dilemmas? A proposed conceptual model based on the literature has been developed for this purpose by the researcher and has subsequently been tested through research questions 1 and 2.

To achieve these research objectives, a study involving both individuals and teams of engineering students solving ethical dilemmas was proposed. Junior and senior engineering students were elicited from two courses in engineering ethics (ENGR 1500 and BIOENG 1241) as well as from the general engineering student body. Both individuals and teams of students were videotaped solving two ethical dilemmas. Analysis of resulting videotapes was used to determine if differences between the comparison groups exist and to document the process(es) that are employed when solving ethical dilemmas/cases.

For lower moral intensity situations the results of this study show that knowing engineering ethics is critical as the students consistently perform better, that is provide a better solution, than students without ethics training whether working in teams or as individuals. For Team versus Individual comparisons the results show that students working in Teams performed better than students working as Individuals on the Resolution and Overall Score. For higher moral intensity situations overall there is no difference between students who had engineering ethics versus those who did not. In fact, contrary to what was hypothesized Ethics Individuals performed better than Ethics Teams for Information, Perspective, and Overall Score.

The results of behavioral observation of the process show that in general Teams spent more time than Individuals on Analysis while subjects with ethics training whether working in Teams or as Individuals spent more time on Recognition of Ethical Dilemma and Information gathering. Also, in case of lower moral intensity situation, Ethics subjects spent more time than No Ethics subjects on Perspective categories.

Regression analysis models using the data for the two cases studied provide a number of important variables to the ethical dilemma resolution. The derived models show that Ethics

Class, Teams, Work Experience, Gender, Major, and case's moral intensity (Case-variable) are significant predictors of Resolution/Report Quality.

This dissertation is organized in the following manner. First a literature review is provided in Chapter 2. The literature review provides a definition of engineering ethics and how it is currently taught in the US. In addition, several ethical decision making models are presented along with specific research on moral decision making and groups, as well as methods/instruments typically used to measure ethical reasoning. This background literature has been used to develop an *Ethical Decision Making in Engineering Model* that is presented and explained in Chapter 3. The methodology section (Chapter 4) focuses on how this model is used along with a proposed experimental study to answer the research questions posed. Chapters 5 through Chapter 8 describe the results of the research experiment. Finally Chapter 9 discusses the outcomes and potential significance of this research and how it furthers the field of ethical decision making in engineering. In Chapter 10, recommendations for future work are presented.

2.0 LITERATURE REVIEW

Over the past twenty-five years, substantial research involving professional ethical issues has been conducted. Much of the research has focused primarily on business ethics and the individual decision making process. The focus of this literature review falls into several areas: (1) a definition of ethics from the engineering perspective, (2) a discussion of the primary theoretical models that explain how ethical decisions are made, (3) a review of studies on moral decision making and groups in business, and (4) an overview of the primary measurement instruments that have been used in this research arena to evaluate aspects of ethical decision making. Unfortunately, very little research has been reported on how to "satisfy" engineering criterion 3-f. In section 2.6 of the Literature Review approaches for how ethics is currently taught in engineering curricula are reported.

2.1 ENGINEERING ETHICS DEFINITION

Although various engineering societies have had codes of ethics for several decades, the academic discipline of engineering ethics appears to have originated in the mid-1970s when engineering and philosophy professors began to consider ethical problems facing engineers. In addition, disciplines such as behavior and management sciences, law, history, and religious studies, as well as developments in other applied ethics fields treating professional responsibility, such as medical, legal, and business ethics have shaped the emerging field of engineering ethics (Lynch, Winter 1997/1998).

Following Martin and Schinzinger's (2000, pp. 8-9) definition, the word "ethics" has several although related meanings. "In the sense used most often, ethics refers to an area of inquiry. *Engineering ethics* accordingly is the study of the moral values, issues and decisions involved in engineering practice… In the second sense, the word *ethics* refers to the particular *beliefs* or *attitudes* concerning morality that are endorsed by specific groups or individuals. Using this sense, engineering ethics consists of the requirements specified in the currently accepted codes of ethics… In the third sense, the word ethics and its grammatical variants are synonyms for "morally correct" or justified. In this usage, engineering ethics amounts to the set of justified moral principles of obligation, rights and ideals that ought to be endorsed, as they apply generally and to engineering in particular, by those engaged in engineering. Clarifying such principles and applying them to concrete situations is the central goal of engineering ethics as an area of study."

Pinkus, Shuman, Hummon, and Wolfe (1997) presented a framework for engineering ethics that is based on the assumption that the engineer is a moral agent. Furthermore an ethical engineer is one who is competent, responsible, and respectful of Cicero's Creed II. Competence involves both the acquisition of relevant knowledge, and the recognition of what is not known. Responsibility involves communicating concerns about both what he engineer knows and does not know about the particular problem of concern to the organization. Cicero's Creed, perhaps engineering's oldest ethic directed engineers to place the safety of the public above all else. Through Cicero's Creed II they added specificity to the original creed by asserting that an ethical engineer be knowledgeable regarding the risk to the public including assessment of the failure characteristics of a given technology.

2.2 ETHICAL DECISION MODELS

In the past 30 years a number of researchers have developed models involving ethical judgments. These models can be grouped into two types: descriptive or positive models and prescriptive or normative models. Descriptive (positive) models are based on the cognitive processes individuals actually use in making decisions involving ethical judgments. These models describe ethical behavior that *actually occurs* in the organization and identify those variables that actually influence the ethical decision making process. In contrast, prescriptive or normative models often assume absolute truths about appropriate decision making and address behavior that should follow. Prescriptive models often resemble a flow diagram or a set of rules for how to make an optimum or correct decision for the particular situation in question. As a result, many such models are limited in their application to the types of scenarios for which they were developed. It is this criticism of normative models that led to the development of descriptive models that seek to uncover important factors in a decision process involving ethical issues (Loe, Ferrell, and Mansfield, 2000). Such variables include personal factors, organizational factors, as well as characteristics of the dilemma, to name a few.

The number of normative models (there are at least fifty) tends to indicate that there is a need for a prescriptive approach to ethical decision making, a need to know what decision will be optimal and how to arrive at an appropriate solution. On the other hand, a chronological review of descriptive models illustrates a need to determine the factors or variables and philosophical principles that actually influence ethical decision making.

Two primary models have been adopted for this research: Jones' (1991) *Synthesis of Ethical Decision Making* model (a positive model and one developed from the business ethics perspective) and the Harris, Pritchard and Rabins model (1999) widely used in engineering education (a normative model). A discussion of the evolution of Jones' model and a description of the Harris Prichard, and Rabins model are presented below.

2.2.1 Positive Models that Have Led to the Development of Jones' Model

Several positive models have appeared in the business literature since 1985. The following five models have led Jones to develop his *Synthesis of Ethical Decision Making Model* that will be used in this research.

In 1985, Ferrell and Gresham presented a C*ontingency Model of Ethical Decision Making in a Marketing Organization*, a model that focuses on the contingent factors (knowledge, values, intentions, and attitudes) that affect the individual decision maker, as well as on the organizational determinants of significant others (differential association and role-set configuration) and opportunity (professional codes, corporate policy, rewards and punishments). The model suggests that management has control over ethical decision making in the organization.

Following this model, Hunt and Vitell (1985) developed a *General Theory of Marketing Ethics* model. The focus in this model is the way in which an individual perceives the situation, alternatives, and consequences. They suggest that once the individual perceives the set of alternatives, a deontological evaluation and teleological evaluation takes place. Deontological norms represent personal rules or rules of behavior which range from beliefs about such things as cheating, product safety, honesty and confidentiality of data. In deontological evaluation the individual evaluates the inherent rightness or wrongness of the intended behavior. At relatively the same time, Trevino presented her *Interactionist Model of Ethical Decision Making in Organizations.* This model is “interactionist” in nature because it combines individual variables with situational variables to explain and predict ethical decision making behavior of individuals in organizations. This model is based on Kohlberg’s cognitive moral development model. Trevino considers Kohlberg‘s cognitive moral development theory as “the most popular and tested theory of moral reasoning” (Trevino, 1986). Further, the model assumes that the individual’s cognitive moral development stage “determines how an individual thinks about ethical dilemmas…and how additional individual and situational variables interact with the cognitive component to determine how an individual is likely to behave in response to an ethical dilemma” (Trevino, 1986, p.602).

Also in 1986, Rest published his *Ethics Model* based on the theoretical development of Kohlberg’s theory of cognitive moral development and Ajzen & Fishbein’s theory of reasoned action (Ajzen and Fishbein, 1975). The premise of the model is that behavior is preceded by behavioral intentions that are, in turn, preceded by individual moral judgments when a moral issue has been recognized.

In 1989, Dubinsky and Loken presented the *Model for Analyzing Ethical Decision Making in Marketing* based on the theory of reasoned action. The model starts with behavioral beliefs, outcome evaluations, normative beliefs, and the motivation to comply. These first two components affect attitudes toward ethical/unethical behavior while the other two affect subjective norms for toward ethical/unethical behavior. Intentions to engage in ethical/unethical behavior are a result of the individual's evaluation of behavior and beliefs about significant others' approval.

Ferrell, Gresham, and Fraederich (1989) developed the *Synthesis Integrated Model (SIM) of Ethical Decision Making in Business* based on the previous findings of Ferrell and Gresham, and Hunt and Vitell. They identify five stages that occur in the ethical decision making process: identification of ethical issue (awareness), cognitions (stages of cognitive moral development), moral evaluations (deontological and teleological judgments), determination (intentions), and action (ethical/unethical behavior). In the second stage, an individual's level of moral development determines how that individual will deal with the dilemma. In the third stage the individual selects the moral philosophy (this is similar to the Hunt and Vitell model). Intentions from stage four determine actions that are taken in stage five. Organizational culture, opportunity, and individual moderators are variables that affect reasoning process through the first four stages.

Integrating the various models developed by Ferrell and Gresham, Trevino, Hunt and Vitell, and Dubinsky and Loken, Jones (1991) proposed an integrative model of ethical decision making, the *Synthesis of Ethical Decision Making Model*. The chronology of these models is presented in Figure 1. The foundation of this "fused" model is based on his *Issue Contingent Model* (also 1991) that utilizes Rest's four-stage process and introduces the concept that ethical decisions are contingent upon factors that define the characteristics of an ethical dilemma. Jones (1991) collectively refers to these characteristics of moral issue as 'moral intensity'. These characteristics include:

- <u>Magnitude of Consequences:</u> The "sum of the harms" (or benefits) done to the victims (or beneficiaries) of the moral act in question;" (p. 374)

- <u>Probability of Effect:</u> "The probability of effect of the moral act in question is a joint function of the probability that the act in question will actually take place and the act in question will actually cause the harm (benefit) predicted;" (p. 375)
- <u>Social Consensus:</u> "The degree of social agreement that a proposed act is evil (or good);" (p. 375)
- <u>Temporal Immediacy:</u> "The length of time between the present and the onset of consequences of the moral act in question (shorter length of time implies greater immediacy)" (p. 376)
- <u>Concentration of Effect:</u> According to Jones (p.377) "an inverse function of the number of people affected by an act of a give magnitude".
- <u>Proximity:</u> The social, cultural, psychological or physical feeling of "nearness" that the moral agent has with the affected person due to the moral act.

Jones speculates that moral intensity affects every stage of the ethical decision making process. Robin, Reidenbach, and Forrest (1996) evaluated moral intensity and found that the level of moral intensity had a significant impact on both ethical judgments and intentions. One notable feature of the model is that there is no feedback loop following moral behavior.

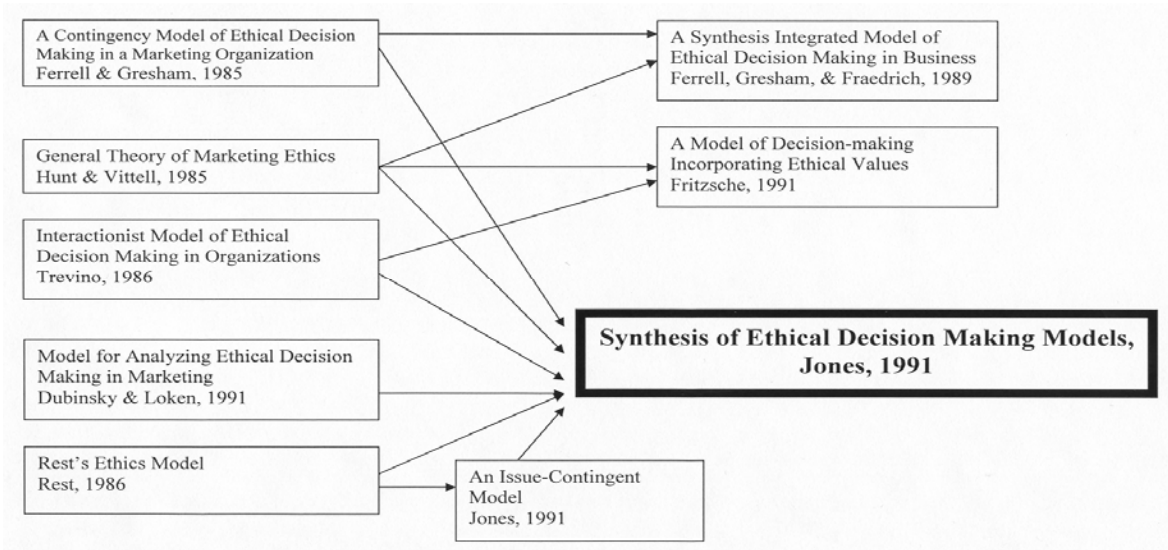


Figure 1 The History that Leads to Jones Model

In synthesizing the models, Jones's provides an overarching model that incorporates the contributions of the individual models to the understanding of ethical decision making, as shown in Figure 2, which the previous models did not explicitly include. Jones included the moral intensity characteristic in the Synthesis of Ethical Decision Making Model (dotted lines). In addition note, the model in Figure 2 is somewhat simplified as it does not include feedback loops.

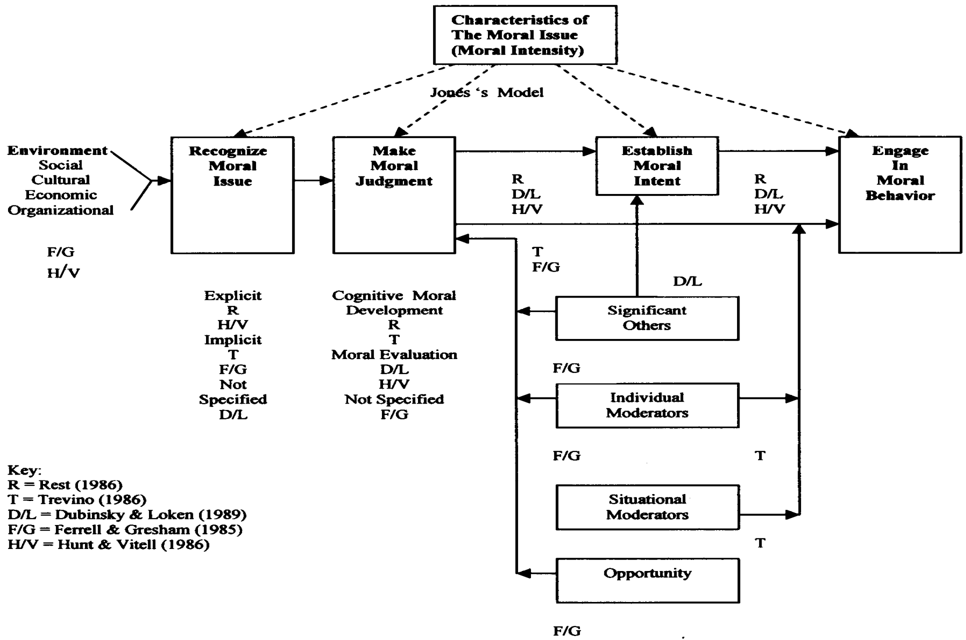


Figure 2 Synthesis of Ethical Decision-Making Models (Adapted from Jones, 1991)

Jones's *Synthesis of Ethical Decision-Making Model* is a focal model for in this research as it builds upon positive models presented and empirically studied in the business literature through 1991. Since 1991 the author is not aware of any other comprehensive positive models presented in the literature. A more complete description of the models described here, as well as other positive models is provided in Appendix A.

2.2.2 Normative Models

As previously mentioned, the literature contains well over fifty normative models. These models are primarily application specific and not comprehensive in nature. However, the model developed by Harris, Pritchard, and Rabins (1999) shown in Figure 3 is one of the most widely taught models for engineering ethical decision making. The procedure in the Harris, Pritchard, and Rabins model (HPR model) is general, not application specific. Therefore, it is not limited to a particular situation, a potential downfall of other normative models.

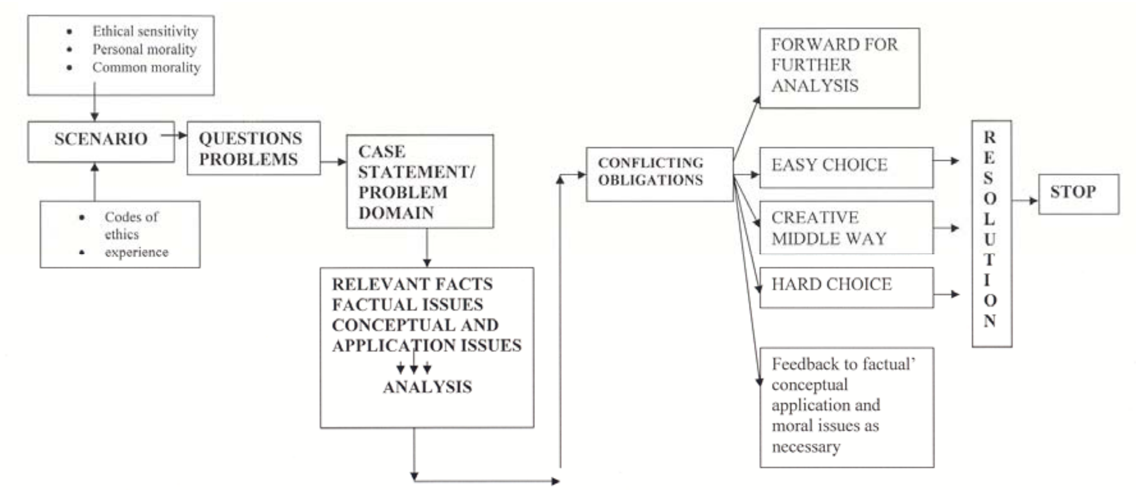


Figure 3 Harris, Pritchard and Rabins Model

Searing (1998) operationalized the HRP methodology for resolving ethical dilemmas following the HPR model and designated it the *HARPS Ethical Analysis Methodology*. Four phases comprise the method: information, issues, analysis, and conclusion.

The *information* phase involves investigating the problem and determining all relevant information including the unknown information (facts). The *issues* phase consists of asking questions about the information gained, clarifying terms and concepts, and finding missing information. During the *analysis* phase several methods of performing analysis (e.g. conflict resolution, line drawing analysis, utilitarian analysis, and respect for persons analysis) may be employed, which, in turn lead to the creation of a solution. This phase frequently requires returning to the issues and information phases. The *conclusion* phase consists of examining the results of all analyses performed and reaching resolution to the problem. A tree-like decision procedure for the HPR model is included in Appendix B, as well as a presentation of several notable normative models.

A combined Jones and HPR model will be utilized in this research. A conceptual model of this is provided in Chapter 3.

2.3 STUDIES ON GROUP MORAL DECISION MAKING

There is certainly an abundance of literature that describes the virtues of teams, arguing that groups contribute to more effective organizational learning, decision making, and problem solving (Bennis, 1997; Goodman, 1996; Hackman, 1990). In organizational settings, the issue of group effectiveness acquired special relevance in recent years with a dramatic increase in the use of work teams, participative management, self-management, and total quality management (TQM) approaches (Guzzo and Salas, 1995; Hackman and Wageman, 1995; Sandstrom, De Meuse, and Futrell, 1990). With respect to ethical decision making, the author is aware of only two studies that have been reported in the literature about groups recognizing and/or solving ethical dilemmas. Nichols and Day (1982) described a study conducted to measure the effect of group interaction on moral decision-making. The effect of group interaction was then compared to individual performance using Defining Issues Test (DIT) scores (Nichols and Day, 1982). Dukerich *et al.,* later focused on two studies that investigated how groups reason about moral dilemmas (Dukerich, Nichols, Elm, and Volrath, 1990). The data indicated that subjects benefited individually from the group experience, but the rationale behind this benefit was not explained.

Both of these studies concentrated on how group work improved the individual's level of moral reasoning as measured by the DIT scores. Rather, because the DIT was used, individual moral reasoning was measured (Kohlberg's level five and six) (Rest, 1997), which is considered one variable in Jones' model. In addition, scenarios typically used in the DIT lacked specific professional applications. Furthermore, both studies were conducted on business school students. Most notably, neither study addresses the *processes* used to arrive at the solution or whether or not groups solve ethical dilemmas better or differently than individuals.

2.4 THE MEASUREMENT OF ETHICS

This section provides an overview of the various approaches researchers have taken towards "measuring ethics." Several survey-like instruments have been developed as well as rubrics that can provide a performance appraisal. Because the measurement of moral development is widely used in ethics studies an overview of the major instruments used is provided.

Among the variables influencing ethical decision making the most studied is the level of moral reasoning. Literature contains several instruments for measuring moral reasoning/moral values. The Character Education Partnership (Assessment Instrument, n.d.) provides an assessment index of the primary instruments used to measure moral reasoning. Those instruments applicable to adult and college level persons are provided in Table 1. As shown in

Table 1, the instruments were evaluated in terms of their ease in administrating and scoring (1=difficult, 2=moderate, 3=easy), as well as reliability and validity (1=low, 2=moderate to marginal, and 3=high).

Table 1 Measurement of Ethics (Adapted from Assessment Instrument Index, n.d.)

Instrument	Age Level	Administration and Scoring	Reliability	Validity
Defining Issues Test (Rest)	All	2	3	3
Rokeach Values Survey (Rokeach)	All	2	3	3
Moral Judgment Interview (Colby)	All	1	3	3
Ethics Position Questionnaire (Forsyth)	College	3	2	2
Social Reflection Questionnaire (Gibbs)	All	2	3	3
World Values Survey (Inglehart)	Adult	2	1	1
Moral Judgment Test (Lind)	All	2	2	2
Universal Values Scale (Schwartz)	Adult	3	1	1
Measure of Moral Values (Hogan)	College	2	3	1

The instruments typically fall into two primary categories: those that "rate" moral development as defined by Kohlberg and those that take or "inventory" of an individual's moral values. These instruments are summarized in the sections that follow.

As a historical note, Lawrence Kohlberg became famous for his theory of moral development in the early 1970s. He demonstrated through his studies that people progressed in their moral reasoning through a series of stages. He believed that there were six stages which could be classified into three levels:

Level 1 (Pre-Conventional

1. Obedience and punishment orientation
2. Self-interest orientation

Level 2 (Conventional)

3. Interpersonal accord and conformity
4. Authority and social-order maintaining orientation

Level 3 (Post-conventional)

5. Social contract orientation
6. Universal ethical principles.

Kohlberg believed that individuals could only progressed through these stages one stage at a time and that most moral development occurs through social interaction; however, he thought that moral development could be promoted through formal education. Kohlberg's stages influenced many in the research field like James Rest in the development of the Defining Issues Test (DIT) in 1979, which is discussed in section 2.4.1 (Kohlberg's Stages, 2009).

2.4.1 Instruments that Measure the Level of Moral Development as Defined by Kohlberg

Moral Judgment Interview (MJI). The Moral Judgment Interview (MJI) was developed in the 1980s with the purpose of operationalizing Kohlberg's theory on the stages of moral development. Kohlberg induced that (1) "morality" is an individually defined, progressive phenomena, and (2) moral judgments result from an individual's cognitive ability to interpret social events (Rest and Navarez, 1994). The initial MJI procedure involved interviewing a subject after being presented with a series of situations involving moral conflicts. The subject is asked to answer a series of open-ended questions that are explicitly prescriptive so as to draw out normative judgments about what one should do, rather than descriptive or predictive judgments about what one would do. These responses enable the researcher to identify a single (or combination of stage(s) of moral reasoning used by the individual. The MJI is designed to elicit a subject's (1) own construction of moral reasoning, (2) moral frame of reference or assumptions about right and wrong, and (3) the way these beliefs and assumptions are used to make and justify moral decisions (Colby and Kohlberg, 1987).

Moral Judgment Test (MJT). The Moral Judgment Test has been constructed to assess subjects' moral judgment competence as it has been defined by Kohlberg: "the capacity to make decisions and judgments which are moral (based on internal principles) and to act in accordance with such judgments" (Lind, 2004). The main index for moral judgment competence, the C-score, of the MJT measures the degree to which a subject's judgments about pro and con arguments are determined by moral points of view rather than by non-moral considerations like opinion-agreement. The C-score ranges from 1 to 100. It indicates the percentage of an individual's total response variation due to a person's concern for the moral quality of given arguments or behavior. The MJT also measures subjects' moral ideals or attitudes, i.e., their attitudes toward each stage of moral reasoning as defined by Kohlberg.

Social Reflection Questionnaire. The Social Reflection Questionnaire measures stages of moral reasoning (Gibbs, Widaman, and Colby, 1982). This method is based on Kohlberg's moral development theories and is simpler than the Moral Judgment Interview but more expansive than Rest's Defining Issues Test.

Defining Issues Test (DIT). Rest developed a non-interview measurement instrument called Defining Issues Test (DIT) and adapted the Kohlbergian perspective using the value of cooperation rather than the value of justice (Rest, 1979). DIT does not rely on the verbal skills of the individual. Measurement of an individual's moral reasoning level is accomplished through the calculation of a P-score or P-index, a weighted index of the percentage of stage five and six (Kohlberg's stage) reasoning used to resolve the dilemmas (Rest, 1979).

DIT is notably the most popular instrument and has been used extensively in over 1,000 studies. Numerous studies reported the test to have reliability in the 0.70 to 0.80 range (Bliasi, 1980; Rest, 1979; Snarey, 1985). Critics such as Kay hypothesized that the DIT actually measures educational achievement, direct moral training, intellectual skills, and social values rather than a distinct developmental process (Kay, 1982). This hypothesis is not supported by other studies (Rest, 1979; Bliasi, 1980; Snarey, 1985).

The DIT is one Moral Level of Development Instrument used in this research.

2.4.2 Instruments that Evaluate or Inventory Moral Values

As mentioned, the second category of "ethics measurement" has been labeled "inventories" of moral values. These instruments aim at describing individuals' ranking of moral values and/or categorizing them into ethical ideologies.

Rokeach Values Survey. American social psychologist Milton Rokeach developed a survey instrument called the Rokeach Value Survey (RVS) in 1973 (Rokeach, 1973). The instrument consists of a rank order exercise whereby the respondent is presented with 18 terminal values (desired goals in life that one thinks are most important and that one feels are most desirable such as freedom, salvation, and equality) and 18 instrumental values (the kind of personal characteristics that one thinks highly of such as cheerful, helpful, and ambitious) and asked to rank them. Rokeach concluded that people attracted to the same occupations tend to show the same value profiles.

Ethics Position Questionnaire (EPQ). Schlenker and Forsyth designed the EPQ (Schlenker and Forsyth, 1977; Forsyth, 1980) to measure ethical ideology along two dimensions: relativism (the extent to which the individual rejects universal moral values when making moral judgments) and idealism (the extent to which the individual idealistically assumes that desirable consequences can, with the "right" action always be obtained). The EPQ seeks to classify individuals into one of four ethical ideologies defined by the authors (situationism, absolutism, subjectivism, and exceptionism).

Universal Values Survey. Following the work of Rokeach, Schwartz (1994) created the Universal Values Survey that began the effort to resolve the issue of classifying value content. Fifty-six values are included in the core survey, 52 represent the ten postulated value types and four capture a possible spirituality type. The values are presented in two lists, the first 30 phrased as terminal values (nouns), and the remaining 26 as instrumental values (adjectives), each followed by an explanatory phrase. This instrument was used to present the theory of the universal aspects of human values.

World Values Survey. Developed by Inglehart (1997) the World Values Survey questionnaire aims at surveying respondents' values in a broad range of areas: cultural, moral, economic and political.

Measure of Moral Values. Hogan and Dickstein (1972) developed a Measure of Moral Values in 1972. The instrument consists of a series of 15 statements each posing a moral issue that were carefully constructed to contain an identifiable element of injustice, expressed in simple matter-of-fact language, and contained the minimum ambiguity consistent with clarity. Responses to statement are graded for "maturity of moral judgment" using the following scoring elements: sanctity of the individual, judgments based on the spirit rather than the law, concern for welfare of society as a whole, and capacity to see both sides of an issue.

A more detailed review of these and other instruments is included in Appendix C.

2.5 THE PITTSBURGH-MINES ENGINEERING ETHICS ASSESSMENT RUBRIC

The afore mentioned instruments currently known in the literature are used to assess a variable or factor in ethical decision-making, specific to the individual's level of moral reasoning or their general moral values. In general, these instruments are not applicable to assess the "*process*" of ethical decision making. The Pittsburgh-Mines Engineering Ethics Assessment Rubric (PMEAR Rubric) developed by Shuman *et. al.,* (2003) evaluates the processes by which individuals make ethical decisions and parallels to the HPR model. For this research, it will be adapted to those processes that teams of engineering students used in the decision making process.

The PMEAR Rubric was developed by a team of researchers from engineering, philosophy, and bioethics from the University of Pittsburgh and Colorado School of Mines. Five attributes are identified each with four levels of achievement designated "1" (lowest) through "5" (highest) for each one of the following attributes.

- Recognition of Dilemma. This attribute rates individuals' on a continuum from not comprehending a problem exists to clearly identifying and framing the key ethical dilemma(s).

- Information. This attribute rates respondents from ignoring pertinent facts to making and justifying assumptions.
- Analysis. This attribute evaluates students from providing no analysis to citing analogous cases with considerations for risk with respect to each alternative.
- Perspective. This attribute evaluates students from no perspective to considering the global view of the situation, as well as perspectives of the employer, the profession, and society.
- Resolution. This ranges from citing rules as resolution (lower level) to the highest level which may include proposing a creative middle ground ("win-win" situation) resolution.

The PMEAR Rubric was used in this study to evaluate the quality of the resolution of the ethical dilemmas and to develop the categories of attributes for the behavioral observation. A copy of the Rubric is located in Appendix D.

2.6 TEACHING OF ENGINEERING ETHICS

The appearance of engineering ethics in the classroom, in the late 1970s, led to engineers and philosophers coming together to conduct projects at Rensselear Polytechnic Institute's Center for the study of the Human Dimensions of Science and Technology and also at the Center for the Study of Ethics in the Professions at Illinois Institute of Technology (CSEP). Support for these projects came from the National Science Foundation (NSF) and the National Endowment for the Humanities (NEH). Specific courses in engineering ethics then started to be developed at a number of other universities (Veil, 1984; Veil, 1985).

Currently, there are four general curriculum models attempted in engineering education: (1) a required course in engineering ethics (Texas A&M), (2) an across-the-curriculum approach (University of Michigan), (3) an integration of engineering ethics and science, technology and society (Virginia School of Engineering and Applied Science, UVA), and (4) a integration of liberal arts into the engineering curriculum (a group of universities led by Illinois Institute of Technology).The "across–the–curriculum" model utilized at the University of Michigan spreads the engineering ethics instruction throughout the engineering curriculum. The "integration" model implemented at UVA requires all engineering students to take a four-course core from the Technology, Culture and Communication (TCC) program. Integration with the overall engineering curriculum is achieved through a required senior thesis on the social impacts of a technical project that is advised by a member of TCC faculty (Herkert, 1999). There currently is a group of universities led by the Illinois Institute of Technology conducting a multi-year project focused on development of traditional courses and across–the–curriculum initiatives (Davis, 2005).

Many engineering schools do not have a model for incorporating engineering ethics into their curriculum. Rather engineering ethics is often an elective, or such a course is only required for certain engineering programs. For example, at the Swanson School of Engineering at the University of Pittsburgh, an elective course in engineering ethics is offered to all junior and senior level engineering students; and in case of bioengineering, a course in engineering ethics (BIOENG 1241) is a required for all seniors prior to graduation.

Nearly all educators understand the need to provide engineering students with some exposure to ethics. Proper training and education prime students to recognize dilemmas, to employ moral imagination, and to recognize compartmentalization when addressing these dilemmas. Also it enables engineers to differentiate between common morality and professional ethics (Harris and Davis, 1996). The complexity of engineering decisions requires close cooperation among engineers of many departments and disciplines, which is especially important when there is a need to tackle morally complex problems (Schinzinger and Martin, 2000). The study of how teams of engineers and individuals make decisions involving ethical dilemmas and the evaluation of what factors play a role in the ethical decision-making process may help to inform future curricula.

3.0 CONCEPTUAL MODEL FOR ETHICAL DECISION MAKING IN ENGINEERING

For the purpose of this research two models: the positive Jones model and the normative Harris, Pritchard, and Rabins (HPR) model were combined to create a conceptual model for studying both individuals and teams of engineering students, as shown in Figure 4. The conceptual model was further enhanced with five categories of factors influencing the decision making process. The factors in the conceptual model include those from the business literature review as provided initially, in the Jones Synthesis Model, as well as factors proposed by the author proposes. The conceptual model, entitled Ethical *Decision Making in Engineering* is shown in Figure 1 where *team component* is highlighted with dash lines.

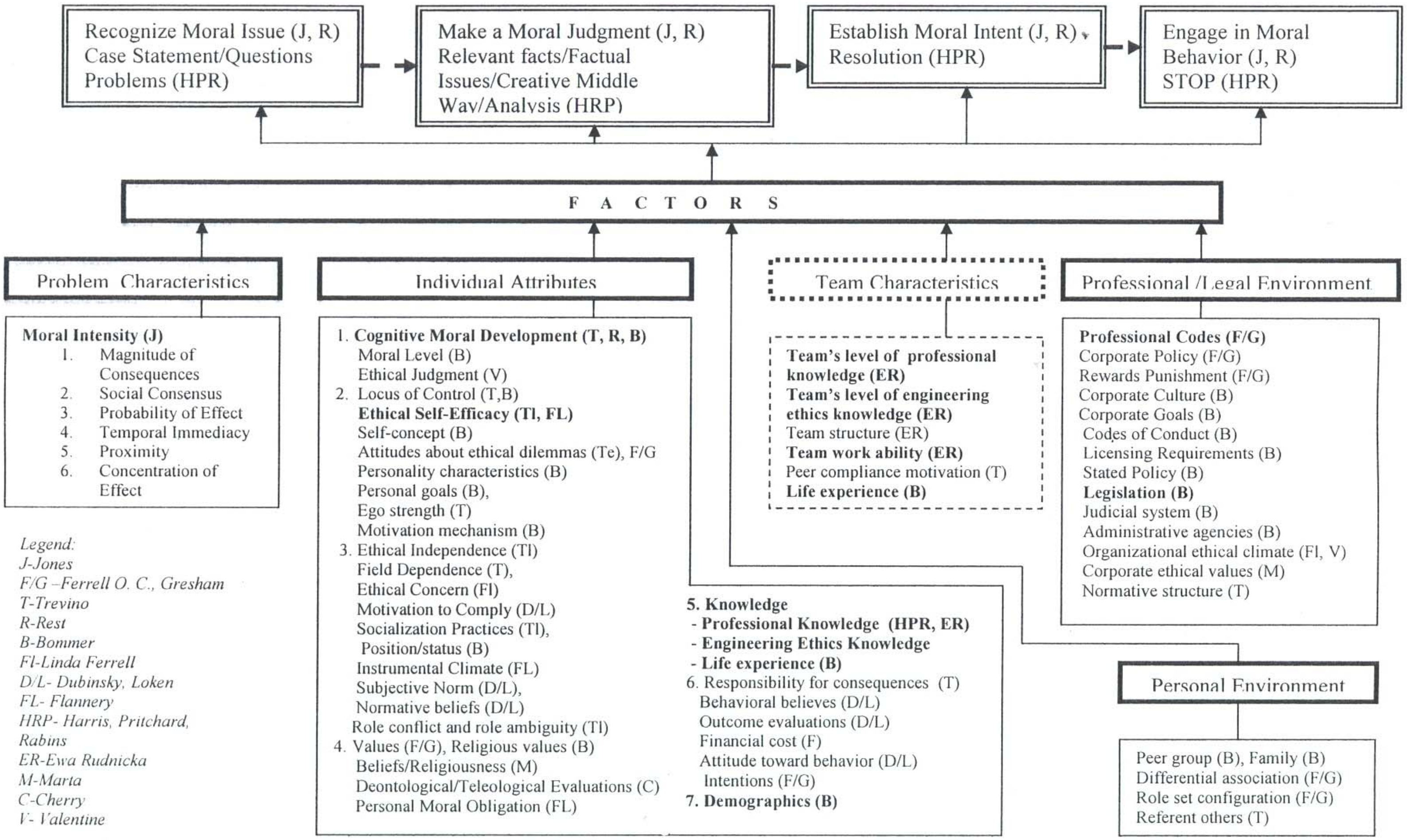


Figure 4 Ethical Decision Making in Engineering Model

(Legend: J = Jones (1991); F/G = Ferrell, O., Gresham, G. (1985); T = Trevino (1986); R = Rest (1986); B = Bommer (Boomer, Gratto, Gravender and Tuttle, 1987) ; Fl = Ferrell, L.(Ferrell, 1996); D/L = Dubinsky, Loken (1989); Fl = Flannery (1997); HRP = Harris, Pritchard, Rabins(1999); ER = Rudnicka (2006); M = Marta (1996); C = Cherry(1996); V = Valentine (1999); Te = Teague (1997))

The model incorporates the ethical decision-making process as well as a selected list of factors influencing ethical decision making in engineering. The various "factors" that contribute to ethical decision making, as cited by the literature are grouped into five categories. With the exception of "Team Characteristics," these categories have been previously defined by the literature as follows:

1. *Problem characteristics*: level of problem's moral intensity;
2. *Individual attributes*: cognitive moral development level, moral level, ethical judgment, locus of control, ethical self-efficacy, self concept, attitudes about ethical dilemmas, personality characteristics, personal goals, ego strength, motivation mechanism, ethical independence, field dependence, ethical concern, motivation to comply, socialization practices, position/status, instrumental climate, subjective norm, normative beliefs, role conflict and role ambiguity, values, beliefs/religiousness, deontological/teleological evaluations, personal moral obligation, professional knowledge, engineering ethics knowledge, life experience, responsibility for consequences, behavioral beliefs, outcome evaluations, financial cost, attitude toward behavior, intentions, and demographics;
3. *Personal environment*: peer group, family, differential association, role set configuration and referent others;
4. *Team characteristics*: team's level of professional knowledge, team's level of engineering ethics knowledge, life experience, team structure, team work ability, peer compliance motivation; and,
5. *Professional/legal environment*: professional codes, corporate policy, rewards/punishment, corporate culture, corporate goals, codes of conduct, licensing

requirement, stated policy, legislation, judicial system, administrative agencies, organizational ethical climate, corporate ethical values, and normative structure.

As shown in Figure 4 each factor has been identified in the literature (note authors' initials). In addition, the *Individual Attributes* in the conceptual model have been further categorized by the author along seven sub-groups: (1) level of moral development, (2) view of self, (3) view of self versus the peer environment/organization, (4) one's religious moral values, (5) one's knowledge, (6) one's ethical behavior/responsibility for consequences, and (7) one's demographics.

Those factors shown in bold letters will be used in this particular research and will be discussed in detail in the methodology section. Tables 1-5 of Appendix E provide definitions for each factor in the model with the various instruments that have been used in prior research where applicable. Further, a review of the experimental studies for which the variables/factors were used (particular to the business literature) is included in Appendix F.

4.0 METHODOLOGY

As discussed, the overreaching purpose of this research was to determine how individuals versus teams of engineering students solving ethical dilemmas differ in terms of the processes used and the quality of the resolution. To evaluate the research questions, an experiment was developed to evaluate the proposed *Ethical Decision Making in Engineering Model*. This experiment evaluated both individual engineering students as well as teams of engineering students working on two ethical dilemmas. Factors as proposed by Jones as well as those processes that engineers should engage in when solving ethical dilemmas (as described by Harris, Pritchard, and Rabins) were measured and assessed.

Specifically, the experiment involved both teams of engineering students and individuals solving engineering based ethical dilemmas. Further, about half of the participants (22 students) had a course in engineering ethics (ENGR 1500 or BIOENG 1241); and the other half (21 students) had no formal training in engineering ethical decision making. Table 2 provides a description of the experimental design with the number of participants. Both the teams and individuals were videotaped while they completed their assigned tasks. This allowed the researcher to observe and assess the *processes* that teams and individuals used while solving the ethical dilemmas. The number of individuals and teams shown in Table 2 was selected based on enrollments in engineering ethics course at the University of Pittsburgh Swanson School of Engineering.

Table 2 Experimental Design with Number of Participants/Teams

Student Level	**Exposure to Formal Engineering Ethics Instruction**		**No Exposure to Formal Engineering Ethics Instruction**	
	Individuals	Teams	Individuals	Teams
Junior/Senior Engineering Students	7	5 (3 people per team)	9	4 (3 people per team)
Total	7	15	9	12

In addition to resolving the ethical dilemmas, participants were asked to complete a number of ethics and team-related instruments that had been developed and used in previous studies. These instruments reflected the various factors presented in Figure 4. To study the "processes" that engineering students used while resolving ethical dilemmas, the rubric proposed by Shuman *et al.* was modified for behavioral observation. Data from the experiment was analyzed using descriptive statistics and hypothesis testing to determine significant factors. An empirical model was then developed relating the factors and process variables to the quality of the resolution.

The following sections outline the instruments and methodologies used to evaluate the conceptual model, along with a description of the study participants, the data collection process, analysis, and use of experimental facilities.

4.1 INSTRUMENTS AND METHODOLOGIES USED TO EVALUATE THE CONCEPTUAL MODEL

From Figure 4, at least one variable from each factor determined to be suitable for the subject pool that we used was chosen to be evaluated (these variables are shown in bold on the proposed conceptual model on Figure 4). Table 3 provides a description of each factor/variable, the instrument, or methodology used to measure the variable, as well as how it was intended to be administered in the experiment. The factor "individual attributes" consists of several sub-factors or sub-variables. Where applicable, a single instrument/method was selected to measure the particular sub-variable. Where appropriate, research studies that have used the specific selected instruments are denoted in the Table 3 as well.

As indicated, the variables selected for this study represent the major categories of factors in the conceptual model. For "Problem Characteristics" the literature indicates that the problem's moral intensity affects the depth of the solution (Jones, 1991). The "moral intensity" of a problem for the two cases in this study was evaluated using the instrument designed by Barnett *et al.*, (Barnett, Brown and Herbert, 1999; Barnett, 2001). Two experts in engineering ethics rated the two dilemmas "moral intensity" and the results confirmed that the two cases used in the study had significantly different moral intensity levels: Case 1 had a relatively low moral intensity level while Case 2 had a higher moral intensity level.

Table 3 Proposed Instruments to Use from the Conceptual Model

Factor	Instrument/Measurement	Administration	Comments
Problem Characteristics	**Moral Intensity** A scaled instrument developed by Barnett, Brown, and Bass (1999) was used.	The scaled instrument took roughly ten minutes per scenario/ dilemma	Two experts rated the scenarios/dilemmas to provide a standard for comparison purposes.
Individual Characteristics	**1. Level of Moral Development** Cognitive Moral Development Level The Defining Issues Test (DIT) described previously was used to measure the level of cognitive moral development.	This closed form instrument took approximately 50 minutes for an individual to take	Each individual or person on a team took the DIT prior to completing the ethical dilemmas.
	3. Knowledge Professional knowledge was measured in various ways: engineering knowledge (number of courses in field and QPA for these courses), engineering ethics knowledge (whether or not they have taken an engineering ethics course or related course and the grade for this course), and professional work experience (number of equivalent semesters of co-op or internship).	This information was acquired through student transcripts and a short five minutes demographic survey	Each individual or person on a team completed the survey prior to completing the ethical dilemmas
	4. Demographics Age, gender, engineering major was collected from each individual.	This information was acquired through a short five minutes demographic survey	Each individual or person on a team completed the survey prior to completing the ethical dilemma.
Team Characteristics	**1. Team Work Ability** The *Professional Developer*™ was used to obtain both a self-assessment of one's team work abilities as well as peer evaluations of each person	This instrument took approximately 20 minutes to complete using a web version of the instrument.	Each individual participating on a team was asked to complete the assessment at the end of the study.
	2. Team's Level of Professional Knowledge This information was obtained through Individual Characteristic (see 3. Knowledge).	N/A	N/A
	3. Team's Level of Engineering Ethics This information through Individual Characteristics item 3.	N/A	N/A
Professional/ Legal Environment	**1. Professional Codes** Use of professional codes was obtained through behavioral observation	N/A	This was observed for both individuals and teams but not evaluated
	2. Legislation Use of related legislation was obtained through behavioral observation	N/A	This was observed for both individuals and teams but not evaluated

As shown in Table 3 there are four sub-factors (or sub-variables) for the "Individual attributes" factor; and the *cognitive moral development level* is the primary individual attribute affecting the solution as evidenced by a number of studies. The landmark instrument used to measure cognitive moral development is the DIT; and hence was selected for this study. To measure *view of self*, the Ethical Self-Efficacy Scale Instrument was utilized. This instrument rates an individual's perceptions regarding job skills, job qualifications, and the ability to perform on the job. It was chosen for the study as a major characteristic of how an individual views himself/herself. The third attribute, *view of self vs. the peer environment and organization* was not used in this study because the subjects were students who were not in a professional organizational setting. The *religiousness/moral values* variable was also not evaluated as the researcher did not think this variable would produce sufficient variation in this particular study, (i.e., most of the research conducted in this area has looked at a global religion perspective not a local religion perspective). For the *professional knowledge* category both students' formal exposure to engineering ethics (having had a course in engineering ethics) as well as professional experience (number of engineering courses, GPA, and number of equivalent semesters of engineering work experience) data were used. QPA was used as surrogate means of professional knowledge because the subjects were undergraduate students with generally limited work experience. Intuitively these attributes can affect the quality of the resolution and the quality of the process. The *responsibility for consequences* variable was not evaluated in this study because the individuals/teams conducting the experiment could only present a solution, not implement it; and thus the actual ethical behavior could not be captured. Finally, typical *demographic* information was collected (age, gender, engineering major).

For this study *team characteristics* included the level of engineering knowledge, level of engineering ethics knowledge, life experience, and teamwork ability. The Professional Developer™ was used as an instrument to evaluate an individual's teamwork ability.

For the *Professional/legal environment* element of the model, professional codes and legislation were the two factors evaluated in this study through behavioral observation. During the behavioral observation, indications of the use of codes and legislation were specifically denoted.

Personal environment was not evaluated in this experiment. It is believed that the subject pool was too homogenous in terms of peer group, family background, etc.

To evaluate those processes that engineering students use when solving ethical dilemmas, a behavioral observation method was employed using an approach by Besterfield-Sacre (2004) and Besterfield-Sacre, Newcome, Shuman and Wolfe (2004). Ethical understanding and ethical problem solving skills entail various processes that can be best evaluated using 100% behavioral observation to effectively capture process oriented outcome. Behavioral observation is desirable because it enables researchers to investigate engineering learning in real time (Brereton, Greeno, Lewis, Linde and Leifer, 1996; Bucciarelli, 1994). The attributes that were observed were the attributes provided by the Shuman *et. al*., (2003) rubric. Additional attributes (researcher cannot tell, non-productive activity, etc.) were included as needed so that the observable attributes were exhaustive. In conducting the behavioral observation, the time that each team member spends on a particular attribute was recorded in sequence. Once the tape was completed, the researcher had knowledge of the amount of time spent on each attribute.

To proceed with the behavioral observations, first a set of distinct, observable and comprehensive attributes of ethical problem solving was developed by the researcher in conjunction with a funded research project (Besterfield-Sacre, Wolfe and Shuman, 2002-2006). The selection of attributes was closely based on the attributes included in the PMEAR Rubric and augmented by three additional attributes: “negative impact/not on task,” “waiting/no negative impact,” and “do not know.” For each attribute visual and audio cues were developed through pilot studies. The complete list of ethical problem solving attributes, their definitions, visual queues, and audio queues is given in Table 4.

To judge the quality of the process by which a decision was made, each case study response was evaluated using the PMEAR Rubric developed by Shuman *et al.* (2003). This instrument was previously discussed in detail in section 2.5.

Table 4 Observable Attributes, Definitions, Visual Queues, and Audio Queues for Ethical Problem Solving

Category	**Attribute**	**Basic Definition**	**Visual Queues**	**Audio Queues**
1	**Recognition of Dilemma**	This category outlines when a subject recognizes one of the key ethical dilemmas. This task is a single subject attribute (only reflective on the original speaker of the statement and not upon the rest of the group).	None	A statement by a subject that initially points out one of the major ethical issues involved in the case being studied.
2	**Information**	This category outlines when a subject is reading or speaking of material that is already currently present in the case study document given. This does not include any analysis into the case study. This attribute also contains managerial tasks as well as rereading to the group previously written conclusions. This can be a single subject or multiple subjects' task.	When the subject is reading or is looking at the original document presented to them Typing only the facts of the case presented in the original document (a note sheet or outline of just the relevant facts)	Speaking between group members only about the facts presented, without going into the analysis of why or why not they are ethical/unethical.
3	**Analysis**	This category outlines when a subject is analyzing the facts in terms of how they relate and their contribution to the ethical problem at hand. This is a multiple subject task, meaning that it is reflective on other subjects if they are listening or actively participating in the conversation (in terms of analysis discussion).	From the listener's perspective, if they appear focused on the person speaking (in term of analysis) or seem anyway involved in the conversation. No typing is involved in the category. All typing of analysis is considered part of the resolution, as the group's written analysis is actually part of their final conclusion (resolution).	Speaking between group members in terms of analysis of the case. These conversations deal with the understanding of how the facts may/may not play a functional role in the ethical problems presented in the case.
4	**Perspective**	This category outlines when a subject brings an outside perspective in to the conversation. This will mainly pertain to outside examples that may seem relevant in understanding the case (how the Challenger case could play a significant role in understanding Case Study #2). This is a single subject category.	None	A statement by a subject of a relevant outside case that reflects on the current case study.

Table 4 (continued)

Category	Attribute	Basic Definition	Visual Queues	Audio Queues
5	**Resolution**	This category outlines when a subject is speaking in terms of their overall conclusion of their analysis. This attribute is only referenced to the subject speaking of the resolution and not of those listening (listening will be listed under Analysis). While generally a single subject attribute, it can be also a multiple subject category when one subject is stating the resolution while another subject dictates the resolution on the computer or paper. Both subjects in this case would be considered in this category. All typing of non-informational nature is also included in this category.	Subject is typing in terms of analysis or resolutions.	Subject is speaking of the final conclusion of their analysis.
6	**Negative Impact/Not On Task**	This attribute outlines any actions that have a negative impact on the project. Negative impact can be defined as any action by a subject(s) that are off task of the project. This category can be single or multiple subjects related.	In most cases this will include playing with objects on the table and eating (though subjects may be able to eat while actively listening, so this may be an area where the observer may make their best judgment on the case in point).	Any conversations that are not within the scope of the project are deemed to be not on task and would be included in this category.
7	**Waiting**	This category outlines when a subject is waiting (but not negatively impacting) on another member to perform some task. This is a single subject attribute.	Waiting for another subject to finish typing is one example of this.	None
8	**Do Not Know**	This category was established for rare occurrences where the subject may not be in visual view, heard via audio, or the viewer is completely unsure of the subject's categorical status. This is rarely used in most case studies performed.	Subject outside of the viewing window/camera.	Audio is muffled or subject cannot be heard.

4.2 SUBJECT POOL

4.2.1 Target Courses for Ethics and No Ethics Students and Recruitment Procedures

The participant pool was drawn from enrolled students at the University of Pittsburgh Swanson School of Engineering. Both junior and senior engineering students were elicited for the experiment via the distribution of a recruitment flyer in several classes. In addition, students who had or were within the last few weeks of completing an engineering or bio-engineering ethics course, specifically ENGR1500 (Ethical Dilemmas: Balancing Cost, Risk and Schedule) or BIOENG 1241 (Societal, Political, and Ethical Issues in Bioengineering), were elicited to participate. The ENGR 1500 elective course primarily consisted of junior and senior engineering students from a variety of engineering programs while BIOENG 1241 consisted of bioengineering students only. Both of these ethics courses use the same required textbook and case study approach. In addition, the BIOENG 1241 uses additional required readings specific to the discipline of bioengineering. The ENGR 1500 also uses additional required readings but not specific to a particular engineering field. The other sample of students was drawn from junior and senior engineering students not exposed to engineering ethics from a variety of engineering disciplines through the means of recruitment flyer. Students volunteered to either work in groups or as individuals. All team members were either trained or not trained in engineering ethics (via one of the two courses mentioned) and could work only as team members or as individuals. A copy of the recruitment flyer is included in Appendix G.

4.2.2 Internal Review Board

The University of Pittsburgh's Internal Review Board (IRB) was contacted and approval was obtained for Human Subjects clearance. Students were informed that participating in the experiment would not impact their course grade, and that their involvement and results would be kept confidential. Successful completion of the project by the students resulted in monetary payment of $65.00 for three to four hours of work.

4.2.3 Enlisted Subjects

Forty-three students participated in the study. Demographic data about gender, age, academic status, ethics course taken and years of experience were collected for each student. Twenty-one students were male and twenty-two were female. Eighteen subjects were twenty-one years old, sixteen subjects were twenty-two years old, seven subjects were twenty-three years old, one was twenty-four years old, and one student was thirty-five years old. All but one student were seniors; the one student was a junior. Students came from three departments: 16 were industrial engineering, 16 were bioengineering, and eleven were civil engineering students. Out of 22 students who took an engineering ethics course, 13 took the ENGR1500 and nine took the BIOENG 1241 class. Twenty-one students did not take an engineering ethics class. Among the engineering ethics students, two had taken additional non-engineering ethics courses. Three of the students in the group of "no engineering ethics" had taken a non-engineering ethics course.

Thirty-three out of 43 students stated some degree of work experience ranging from 0.25 years to 4 years. A summary of work experience is provided in Figure 5. It should be noted that engineering students can participate in the cooperative (co-op) program and, hence, many gain professional experience.

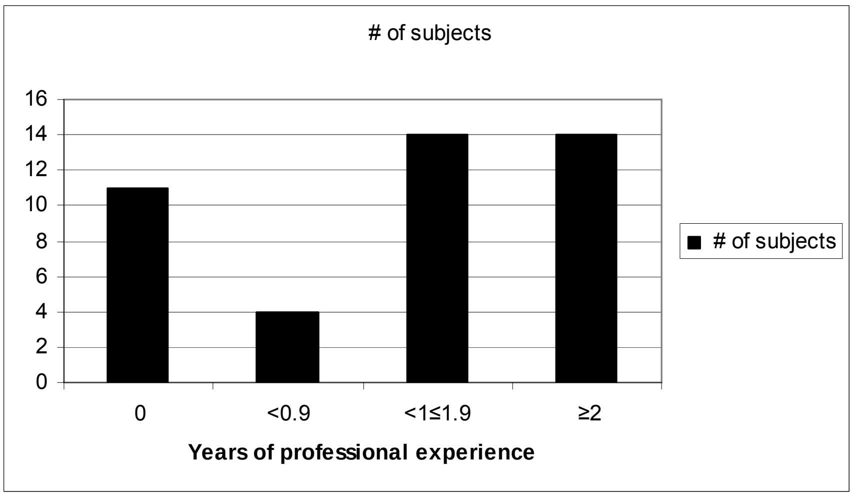


Figure 5 Years of Professional Experience

4.3 EXPERIMENTAL LOGISTICS AND FACILITIES

4.3.1 Facility

The experiment took place in a secured room of the Engineering Student Observation Studio of the University of Pittsburgh's Industrial Engineering Department. This room was equipped with a secured sensor-tripped camera strategically placed to record student group activities. An attached editing room allowed for quick editing of videotapes. This room was secured for this project by Dr. Besterfield-Sacre, who developed it under a separate research grant. The room was equipped with a table large enough to seat four people comfortably, a large white board, and a computer with MS Office and internet capabilities.

4.3.2 Studio Scheduling

The groups/individuals were scheduled to analyze first Case 1, then on another day Case 2. Groups/individuals were allowed up to 120 minutes per case scenario to discuss and create their responses (there were no groups/individuals that needed additional time). The time allowed was determined to be sufficient based on the pilot study.

4.3.3 Experimental Procedures

Prior to the experiment, students were asked to complete the various instruments indicated in Section 4.1. The survey/instruments took approximately one hour per person. For those individuals working on teams, they had the additional requirement of individually completing the *Professional Developer* upon the completion of the cases' analysis. This took no more than 20 minutes.

Before entering the Engineering Student Observation Studio the participants were given the case script. Groups were instructed to discuss the case and then provide a written analysis on a sheet of paper describing any potential ethical problem(s) facing any of the actors (characters) in the case, as well as discuss possible resolutions including their preferred resolution with supporting justification. The sessions were videotaped for the analysis. Similarly, individuals were presented with the same two case scenarios and given up to 120 minutes to "think out loud" about each case and provide their written responses. These verbal protocols were also video taped while students worked on resolving the scenarios. For both groups and individuals, the completed written reports (either typewritten or hand written) were to be either left in the room or delivered to the researcher.

Although the verbal protocol and group discussions are different in terms of observation data, it is assumed that a verbal protocol should not affect the cognitive process involved in task performance as there is no indication that concurrent verbalization changes either the sequence or the content of the participant's thoughts. Verbal protocol analysis does require substantial time (Erricsson, as cited in Atman et al., 2007), consequently many studies using this method are either case studies or small sample studies. Protocols have been successfully analyzed using methodologies by other researchers (Mullins, Atman and Shuman, 1999; Atman and Bursic, 1998). As with the groups, individuals also provided written response.

4.4 CASE SCENARIOS

As discussed, two engineering ethical dilemmas were utilized in this experiment. In a previous study investigating moral decision making of engineering students (individuals), cases from Harris and colleagues (Harris, Pritchard and Rabins, 1999) and Ashley and Pinkus (2000) were investigated. The two chosen cases, i.e., The Price is Right (Pritchard, 2007) and Carter Racing (Brittain and Sitkin, 2000), have a substantial depth to provide a significant amount of observational data for the decision making process analysis. Case 1 (The Price is Right) dealt with the ethical issues of part replacement, not informing the client about technical/specification changes, and cost changes. In Case 2 (Carter Racing) the ethical issues involved potential loss of life, safety etc. Copies of Case 1 and Case 2 are included in Appendix H. The teams and individuals were sequentially presented with the two case scenarios: Case 1 followed by Case 2. The cases represented different levels of moral intensity and typical engineering problems involving the issues of Cicero's Creed II (Pinkus, Shuman, Hummon and Wolfe, 1997), as well as engineering competency and responsibility. Two engineering ethics experts evaluated the moral intensity of the cases using an instrument developed by Barnett, Brown and Herbert (1999). The instrument uses a Likert scale and the maximum total score for the moral intensity is 168 points. Case 2 was found to have higher moral intensity than Case 1 as evaluated by the experts and shown in Table 5.

Table 5 Moral Intensity Results for Case 1 and Case 2

Case	Expert A Total score (percent)	Expert B Total score (percent)	Average	Range
Case 1	107 (.64)	88 (.52)	.58	.12
Case 2	119 (.71)	119 (.71)	.71	0

4.5 DATA COLLECTION, ANALYSIS AND MODELING, AND VALIDATION

4.5.1 Data Collection

Data collection was conducted during Spring 2005, Fall 2005, and Spring 2006 semesters. The data were analyzed to evaluate the ability to detect an ethical dilemma, to evaluate the solution quality, evaluate group solving process, and determine the "type of models/procedures" that groups use.

4.5.2 Observer Training

Two graduate student observers who had an understanding of engineering ethics were trained to perform 100% behavioral observations' coding. One observer was highly experienced in behavioral observations; and the other a new trainee. In conducting these observations, only one team member was observed for coding at any one time (i.e., each tape was observed three times one time for each team member). The trainee observer's progress was benchmarked against an experienced observer. Once the trainee observer achieved statistically similar results (i.e., times) the trainee observer completed the rest of the cases/tapes for 100% behavioral observation. The observers were able to achieve consistency after assessing 15 of the 86 observations.

The 100% observations were used to establish the amount of time associated with each of the eight attributes (i.e., aspects of the process). Tapes, as opposed to direct observations, were used in order to increase the accuracy of this research as the observers could re-watch tapes as necessary.

To grade the resultant reports using the PMEAR rubric, two graduate students both with an understanding of engineering ethics randomly selected three reports to grade together. This initial training exercise led to selecting three additional reports that were scored separately then compared. Both resultant scores were very close, and the remaining 19 reports were scored by the researcher so as to maintain consistency of grading. The same procedure was repeated for Case 2 for behavioral observation and written report grading.

4.5.3 Data Analysis, Model Development and Validation

Statistical analysis was conducted on the various factors and process that comprise the conceptual model. Descriptive statistics were used to assess both the individual and team data to inform the researcher on the magnitude and variation of the variables being investigated. Two-sample F-tests for variances and appropriate two-sample t-tests for means were performed at the significance level of $\alpha = 0.10$ (due to the relatively small sample sizes used in this research).

All the categories defined in the PMEAR Rubric were used to evaluate the Quality of the Report, and hypothesis testing was conducted on the means for Individuals and Teams and for Ethics training versus No Ethics training to detect significant differences. The statistical results are discussed in Chapter 5.

Additionally, hypothesis testing was also conducted on the means for Individuals and Teams and for Ethics versus No Ethics training for all of Behavioral Observation categories to detect differences in “time spent” on each category. The statistical results of these comparisons are included in Chapter 6.

Chapter 7 provides a statistical summary of the teams’ perceived abilities and ratings of team members via the Professional Developer.

Finally, regression analysis was employed to detect which of the independent variables included in the Conceptual Model were significant. The results of the regression analysis are discussed in Chapter 8.

5.0 STATISTICAL ANALYSIS FOR THE QUALITY OF THE RESOLUTION USING PMEAR RUBRIC

At the conclusion of the problem solving session each team and each individual prepared a report/solution one for each of the two case studies. The PMEAR Rubric was used to evaluate the "quality" of the cases' resolution (Shuman et al., 2003). In addition, an Overall Score was provided. This score was the rater's perceived average score on how subjects assessed and resolved ethical dilemma. There were nine teams (five Ethics Teams and four No Ethics Teams) and 16 individuals (seven Ethics Individuals and nine No Ethics Individuals) in this study.

For each of the two cases and of the five categories of the PMEAR Rubric, two-sample F-tests for variances and two-sample t-tests for means were performed to determine the following comparisons using terms and definitions provided in Table 6:

- Ethics versus No Ethics:
    1. Ethics Individuals vs No Ethics Individuals,
    2. Ethics Teams vs No Ethics Teams, and
    3. Ethics subjects vs No Ethics subjects.
- Teams versus Individuals:
    1. Teams vs Individuals,
    2. Ethics Teams vs Ethics Individuals, and
    3. No Ethics Teams vs No Ethics Individuals.

Table 6 Terms and Definitions Used for Comparisons

Term	Definition
Ethics Individuals	An individual who took an engineering ethics course and worked on the case alone.
No Ethics Individuals	An individual who did not take an engineering ethics course and worked on the case alone.
Ethics Teams	Teams of three individuals who took an engineering ethics course.
No Ethics Teams	Teams of three individuals who did not take an engineering ethics course.
Ethics subjects	Students who took an engineering ethics course and worked on the cases either as individuals or in a team setting.
No Ethics subjects	Students who did not take an engineering ethics course and worked on the cases either as individuals or in a team setting.
Teams	Ethics Teams and No Ethics Teams
Individuals	Ethics Individuals and No Ethics Individuals

The results of the tests were used to determine if differences exist between Ethics and No Ethics, and Teams and Individuals. Sections 5.1 and 5.3, for Case 1 and Case 2 respectively, provide results to the research question of whether a course in engineering ethics makes a positive difference in the quality of the resolution (Resolution- category 5 and Overall Score-category 6) while the quality of the decision process is evaluated by the remaining categories (Recognition of the Dilemma, Information, Analysis, and Perspective). In sections 5.2 and 5.4, for Case 1 and Case 2 respectively, the differences between Teams and Individuals were tested to determine if the quality of ethical decisions made by groups of engineers were better than those made by individuals.

Lists of hypotheses are provided Tables 7, 11, 15, and 19 followed by a detailed discussion of the results using statistical one tail t-tests with $\alpha = 0.10$.

5.1 CASE 1: REPORT QUALITY FOR ETHICS VERSUS NO ETHICS

The Ethics versus No Ethics hypotheses for Case 1 tested in this research are listed in Table 7 and the statistical results of the comparisons are analyzed in sections 5.1.1-5.1.3. For Case 1 we hypothesized that students with ethics training would perform better (score higher) than those without ethics training on all categories of PMEAR rubric (Recognition of Dilemma, Information, Analysis, Perspective, and Resolution) as well as the Overall Score regardless whether they work in teams or as individuals.

As evidenced by the following statistical results, knowing engineering ethics is critical for engineering students as the students consistently perform better than individuals without ethics training in all categories, whether working in teams or individually.

When working in teams, students with ethics training recognize the ethical dilemma (Recognition of Dilemma, category 1) and analyze problems from different perspectives (category 4) better than students without ethics training working in a team setting. For Information (category 2), Analysis (category 3), and Resolution (category 5) Ethics Teams do not differ from No Ethics Teams. However it should be noted that Information and Analysis are functions that traverse the problem solving process and engineering students have been trained in these elements through other courses. Recognition of an ethical dilemma and viewing multiple Perspectives are typically not “taught.”

Table 7 Case 1 Report Quality: Hypotheses of Differences between Ethics and No Ethics

Hypotheses	Ethics subjects vs No Ethics Subjects	Ethics *Teams* vs No Ethics *Teams*	Ethics *Individuals* vs No Ethics *Individuals*
H1 Recognition of Dilemma	**E>NE**	**E>NE**	**E>NE**
H2 Information	**E>NE**	E>NE	**E>NE**
H3 Analysis	**E>NE**	E>NE	**E>NE**
H4 Perspective	**E>NE**	**E>NE**	**E>NE**
H5 Resolution	**E>NE**	E>NE	**E>NE**
H6 Overall score	**E>NE**	E>NE	**E>NE**
Note: *E=Ethics, NE=No Ethics,* **Boldface***=Confirmed at* $\alpha = 0.10$			

5.1.1 Case 1: Report Quality for Ethics teams versus No Ethics Teams

A summary of statistical results for Ethics subjects versus No Ethics subjects for the Report Quality are included in Table 8. As evidenced by the *P-values* students who took an engineering ethics course produced better quality reports than students with No Ethics course for all the attributes and the overall score considered in the PMEAR Rubric. This is likely due to the training the individuals received when taking engineering ethics course that improved their ability to solve engineering ethics dilemmas.

Table 8 Case 1 Report Quality: Summary of Statistical Results for Ethics versus No Ethics

Attribute	Ethics subjects N=12	No Ethics subjects N=13	Variances	P-value One tail t-test
Recognition of Dilemma	μ=4.21 v=0.157	μ=3.46 v=0.394	Not Equal	**0.001**
Information	μ=3.83 v=0.333	μ=3.08 v=0.394	Not Equal	**0.003**
Analysis	μ=3.63 v=0.333	μ=2.88 v=0.215	Equal	**0.001**
Perspective	μ=3.79 v=0.203	μ=3.23 v=0.192	Equal	**0.002**
Resolution	μ=3.63 v=0.278	μ=3.19 v=0.272	Equal	**0.025**
Overall score	μ=3.75 v=0.250	μ=3.12 v=0.298	Not equal	**0.001**
Note**: μ range 1-5,* **Boldface=Confirmed at α = 0.10*				

5.1.2 Case 1: Report Quality for Ethics Teams vs No Ethics Teams

A summary of the statistical results for Ethics Teams versus No Ethics Teams for the Report Quality of Case 1 is shown in Table 9. The *P-values* indicate that Ethics Teams produced better results that No Ethics Teams for two attributes - Recognition of Dilemma and Perspective. For the other attributes and for the Overall Score the mean scores were not significantly different at the α =0.10 level.

For Information, Analysis, Resolution, and the Overall Score there was not sufficient statistical evidence to state that Ethics Teams performed better than No Ethics Teams. The fact that students worked in a team environment may have facilitated their ability in these three areas regardless of whether or not they had engineering ethics training, as these are typical engineering functions taught and exercised throughout the engineering curriculum, whereas, recognizing the dilemma(s) and understanding the multiple perspectives of parties affected and involved in the dilemma is something specifically addressed in engineering ethics classes. Regardless of these two attributes, the Resolution and Overall Score were not different between the two sets of teams.

Table 9 Case 1 Report Quality: Summary of Statistical Results for Ethics Teams versus No Ethics Teams

Attribute	Ethics Teams N=5	No Ethics Teams N=4	Variances	P-value One tail t-test
Recognition of Dilemma	μ=4.3 v=0.2	μ=3.5 v=0.333	Equal	**0.025**
Information	μ=3.63 v=0.563	μ=3.25 v=0.75	Not equal	0.268
Analysis	μ=3.4 v=0.675	μ=3 v=0.167	Equal	0.204
Perspective	μ=3.9 v=0.300	μ=3.25 v=0.250	Equal	**0.055**
Resolution	μ=3.6 v=0.425	μ=3.63 v=0.063	Equal	0.470
Overall score	μ=3.8 v=0.325	μ=3.38 v=0.299	Equal	0.295
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.1.3 Case 1: Report Quality for Ethics Individuals versus No Ethics Individuals

Table 10 provides a summary of the statistical results for Ethics Individuals versus No Ethics Individuals for the report quality of Case 1. There were seven individuals who took engineering ethics class and nine individuals who did not receive training in engineering ethics. As evidenced by the statistical results, individuals who took an engineering ethics course produced better quality reports than the "No Ethics Individuals" for all the attributes and the overall score considered in the PMEAR Rubric. For Case 1 it appears that training in engineering ethics provides an advantage for the report quality.

Table 10 Case 1 Report Quality: Summary of Statistical Results for Ethics Individuals versus No Ethics Individuals

Attribute	Ethics Individuals N=7	No Ethics Individuals N=9	Variances	P-value Two tail t-test
Recognition of Dilemma	μ=4.14 v=0.143	μ=3.44 v=0.465	Not equal	**0.022**
Information	μ=3.93 v=0.286	μ=3 v=0.313	Not equal	**0.004**
Analysis	μ=3.39 v=0.238	μ=2.83 v=0.25	Not equal	**0.002**
Perspective	μ=3.71 v=0.155	μ=3.22 v=0.194	Not equal	**0.034**
Resolution	μ=3.64 v=0.226	μ=3 v=0.25	Not equal	**0.032**
Overall score	μ=3.71 v=0.238	μ=3 v=0.313	Not equal	**0.016**
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.2 CASE 1: REPORT QUALITY FOR TEAMS VERSUS INDIVIDUALS

The "Teams versus Individuals" hypotheses tested in this research are listed in Table 11. The specific statistical results of the comparisons' are provided in sections 5.2.1-5.2.3. For Case 1 we hypothesized that students working in teams would outperform (score higher) individuals on all categories of PMEAR rubric (Recognition of Dilemma, Information, Analysis, Perspective, and Resolution) as well as the Overall Score; however these hypotheses did not meet the expectation of the researcher.

In general, Teams performed better than Individuals only for the important Resolution category. This is possibly due to the fact that more discussion and points of view were presented by each member of the team, which in turn, lead to a better case resolution. This was observed in the video tapes as the whole team often tried to agree to the final resolution.

Ethics Teams did not satisfactorily differ from Ethics Individuals for any category, which may not be surprising as all subjects had training in engineering ethics. When comparing No Ethics Teams with No Ethics Individuals, teams performed better in the Resolution again confirming that teams can lead to better performance if no ethics training is involved.

Table 11 Case 1 Report Quality: Hypotheses of Differences between Teams and Individuals

Hypotheses	Teams vs Individuals	Ethics Teams vs Ethics Individuals	No Ethics Teams vs No Ethics Individuals
H1 Recognition of Dilemma	T>I	T>I	T>I
H2 Information	T>I	T>I	T>I
H3 Analysis	T>I	T>I	T>I
H4 Perspective	T>I	T>I	T>I
H5 Resolution	**T>I**	T>I	**T>I**
H6 Overall score	T>I	T>I	T>I
Note: *T=Teams, I= Individuals,* **Boldface**=*Confirmed at α = 0.10*			

5.2.1 Case 1: Report Quality for Teams versus Individuals

For a Case 1 a summary of the statistical results for the report quality is given in Table 12. The results show that Teams perform better on Resolution only. Perhaps this could be explained by the fact that when working in a team setting each member brings his or her solution to the discussion resulting in an overall better resolution. For all the other attributes the mean scores are not statistically different. It seems that a team approach, alone, is significantly better than an individual one for one of these two attributes.

Table 12 Case 1 Report Quality: Summary of Statistical Results for Teams versus Individuals

Attribute	Teams N=9	Individuals N=16	Variances	P-value One tail t-test
Recognition of Dilemma	μ=3.94 v=0.403	μ=3.75 v=0.433	Not equal	0.239
Information	μ=3.5 v=0.563	μ=3.41 v=0.507	Not equal	0.381
Analysis	μ=3.22 v=0.444	μ=3.25 v=0.466	Not equal	0.461
Perspective	μ=3.61 v=0.361	μ=3.44 v=0.299	Not equal	0.325
Resolution	μ=3.61 v=0.236	μ=3.28 v=0.322	Not equal	**0.072**
Overall score	μ=3.61 v=0.299	μ=3.31 v=0.396	Not equal	0.115
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.2.2 Case 1: Report Quality for Ethics Teams versus Ethics Individuals

A summary of the statistical results for Ethics Teams versus Ethics Individuals for the quality of the reports is included in Table 13. The statistical tests show that there is no significant difference between Ethics Teams and Ethics Individuals for any of the attributes. So, although students who work in groups have some advantages, it seems that an engineering ethics course prepares students equally well to resolve engineering ethics dilemmas in a team setting, as well as by themselves.

Table 13 Case 1 Report Quality: Summary of Statistical Results for Ethics Teams versus Ethics Individuals

Attribute	Ethics Teams N=5	Ethics Individuals N=7	Variances	P-value One tail t-test
Recognition of Dilemma	μ=4.3 v=0.200	μ=4.14 v=0.143	Equal	0.262
Information	μ=3.7 v=0.450	μ=3.93 v=0.286	Equal	0.263
Analysis	μ=3.4 v=0.675	μ=3.79 v=0.238	Equal	0.165
Perspective	μ=3.9 v=0.300	μ=3.71 v=0.155	Equal	0.449
Resolution	μ=3.6 v=0.425	μ=3.64 v=0.226	Equal	0.449
Overall score	μ=3.8 v=0.325	μ=3.71 v=0.238	Equal	0.393
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.2.3 Case 1: Report Quality for No Ethics Teams versus No Ethics Individuals

From Table 14 it appears that a primary reason for the difference in No Ethics Teams vs. No Ethics Individuals lies in whether or not they worked in teams. Here we see that students working in teams performed better than students working as individuals on Resolution and Overall Score. This is perhaps due to the fact that the team setting lends itself to achieve better resolution than in an individual setting.

Table 14 Case 1 Report Quality: Summary of Statistical Results for No Ethics Teams versus No Ethics Individuals

Attribute	No Ethics Teams N=4	No Ethics Individuals N=9	Variances	P-value One tail t-test
Recognition of Dilemma	μ=3.5 v=0.333	μ=3.44 v=0.465	Not Equal	0.442
Information	μ=3.25 v=0.750	μ=3 v=0.313	Equal	0.270
Analysis	μ=3 v=0.166	μ=2.75 v=0.214	Not Equal	0.186
Perspective	μ=3.25 v=0.250	μ=3.22 v=0.194	Equal	0.334
Resolution	μ=3.63 v=0.063	μ=3 v=0.250	Not Equal	**0.006**
Overall score	μ=3.38 v=0.229	μ=2.94 v=0.317	Not Equal	0.101
Note: *μ range 1-5,* ***Boldface****=Confirmed at α = 0.10*				

5.3 CASE 2: REPORT QUALITY FOR ETHICS VERSUS NO ETHICS

As mentioned in section 4.4 this case was evaluated by two engineering education experts with respect to the moral intensity of ethical engineering issues. Case 2 is much longer than Case 1 and not as straight forward as Case 1. It was used to represent engineering ethics situations that are more "vague" but with a higher "Moral Intensity" level. Table 15 provides the tested hypotheses for students who did or did not have engineering ethics. Comparisons were statistically analyzed and the results are provided in sections 5.3.1-5.3.3.

For Case 2, it was hypothesized that students who had a course in engineering ethics would out perform students who did not have a course, regardless of whether they were on teams or not. However, as shown in Table 15, this is not the case. Overall, there was no difference between students who had engineering ethics vs. those who did not. For Teams, specifically, there were no statistical differences. When comparing Individuals only, students with ethics training performed better in the Information category than those who did not have engineering ethics training.

Table 15 Case 2 Report Quality: Hypotheses of Differences between Ethics and No Ethics

Hypotheses	Ethics subjects vs No Ethics subjects	Ethics Teams vs No Ethics Teams	Ethics Individuals vs No Ethics Individuals
H1 Recognition of Dilemma	E>NE	E>NE	E>NE
H2 Information	E>NE	E>NE	**E>NE**
H3 Analysis	E>NE	E>NE	E>NE
H4 Perspective	E>NE	**E<NE**	E>NE
H5 Resolution	E>NE	E>NE	E>NE
H6 Overall score	E>NE	E>NE	E>NE
Note: *E=Ethics, NE= No Ethics,* **Boldfac***e=Confirmed at α = 0.10*			

5.3.1 Case 2: Report Quality for Ethics Subjects versus No Ethics Subjects

A summary of the statistical results for students who had ethics versus students who did not is included in Table 16. For Case 2 it was found that there were no significant differences in the report quality of the report when comparing students who had engineering ethics versus those who did not. When analyzing the responses provided it appears that the majority of subjects did not recognize the pertinent ethical dilemmas in this case. Many solved the case from a purely monetary value perspective and arrived at similar answers. As many subject (both teams and individuals) failed to recognize the ethical dilemmas all scores for Case 2 were found to be much lower than those for Case 1 along all attributes.

Table 16 Case 2 Report Quality: Summary of Statistical Results for Ethics versus No Ethics

Attribute	Ethics subjects N=12	No Ethics subjects N=13	Variances	P-value One tail t-test
Recognition of Dilemma	μ=1.96 v=0.748	μ=2.15 v=1.474	Not Equal	0.323
Information	μ=2.54 v=0.339	μ=2.35 v=0.474	Not Equal	0.225
Analysis	μ=2.33 v=0.339	μ=2.12 v=256	Equal	0.153
Perspective	μ=2.5 v=0.273	μ=2.54 v=0.894	Equal	0.451
Resolution	μ=2.13 v=0.597	μ=2.19 v=0.647	Not Equal	0.416
Overall score	μ=2.25 v=0.375	μ=2.21 v=0.592	Not Equal	0.445
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.3.2 Case 2: Report Quality for Ethics Teams versus No Ethics Teams

When looking at the differences between teams with engineering ethics and those without, as shown in Table 17. The mean score for the Perspective attribute was statistically higher for teams without ethics than those teams with engineering ethics. We have found no plausible explanation for this result. For all other attributes no significant differences were found between the two sets of teams. At an alpha level of 0.10, you would expect 10% of the test to reject when, in fact, there is no significance. This could be one possibility for this result.

Table 17 Case 2 Report Quality: Summary of Statistical Results for Ethics Teams versus No Ethics Teams

Attribute	Ethics Teams N=5	No Ethics Teams N=4	Variances	P-value One tail t-test
Recognition of Dilemma	μ=1.6 v=0.800	μ=2.25 v=2.250	Not Equal	0.240
Information	μ=2.1 v=0.425	μ=2.38 v=1.229	Not equal	0.339
Analysis	μ=2.2 v=0.325	μ=2.375 v=0.563	Not Equal	0.437
Perspective	μ=2.2 v=0.200	μ=3 v=1.333	Equal	**0.097**
Resolution	μ=1.8 v=0.450	μ=2.63 v=1.229	Not Equal	0.124
Overall score	μ=1.95 v=0.388	μ=2.38 v=1.063	Not Equal	0.250
Note: *μ range 1-5,* ***Boldface****=Confirmed at α = 0.10*				

5.3.3 Case 2: Report Quality for Ethics Individuals versus No Ethics Individuals

Table 18 summarizes the statistical results for Ethics Individuals versus No Ethics Individuals. As Table 18 indicates one attribute, Information shows statistical differences between individuals who had training in engineering ethics versus those who did not. Individuals with engineering ethics received higher average score than Individuals without engineering ethics. Training in engineering ethics possibly enhances the ability to seek better information for this case with higher moral intensity.

Table 18 Case 2 Report Quality: Summary of Statistical Results for Ethics Individuals versus No Ethics Individuals

Attribute	Ethics Individuals N=7	No Ethics Individuals N=9	Variances	P-value One tail t-test
Recognition of Dilemma	μ=2.21 v=0.655	μ=2.11 v=1.361	Not Equal	0.419
Information	μ=2.86 v=0.060	μ=2.33 v=0.250	Not Equal	**0.009**
Analysis	μ=2.43 v=0.286	μ=2.11 v=0.174	Equal	0.101
Perspective	μ=2.71 v=0.238	μ=2.33 v=0.688	Not Equal	0.136
Resolution	μ=2.36 v=0.634	μ=2 v=0.375	Equal	0.164
Overall score	μ=2.46 v=0.300	μ=2.14 v=0.470	Not Equal	0.155
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.4 CASE 2: REPORT QUALITY FOR TEAMS VERSUS INDIVIDUALS

It was hypothesized that teams, in general, would perform better on Case 2 than individuals. Further it was hypothesized that a course in engineering ethics would enable teams to perform better individuals. As Table 19 indicates these hypotheses were not confirmed for Case 2, and for two tests disputed. As noted for Case 2 the scores on the various rubric attributes were lower than for Case 1; both teams and individuals performed relatively worse on the second more complex case.

In the case of Ethics Teams versus Ethics Individuals, Ethics Individuals performed better in Information, Perspective, and Overall Score categories. Perhaps the team convinces themselves that there is no ethical issue; and hence the teams do not perform as well as individuals in these categories.

Statistical results of comparisons for Teams versus Individuals are analyzed in sections 5.4.1.-5.4.3.

Table 19 Case 2 Report Quality: Hypotheses of Differences between Teams and Individuals

Hypotheses	Teams vs Individuals	Ethics Teams vs Ethics Individuals	No Ethics Teams vs No Ethics Individuals
H1 Recognition of Dilemma	T>I	T>I	T>I
H2 Information	T>I	**T<I**	T>I
H3 Analysis	T>I	T>I	T>I
H4 Perspective	T>I	**T<I**	T>I
H5 Resolution	T>I	T>I	T>I
H6 Overall score	T>I	**T<I**	T>I
Note: *T=Teams, I= Individuals,* **Boldface***=Confirmed at α = 0.10*			

5.4.1 Case 2: Report Quality for Teams versus Individuals

Table 20 provides a summary of statistical results for Teams versus Individuals for the report quality. For Case 2 the results show no significant differences for the average scores along any of the attributes.

Table 20 Case 2 Report Quality: Summary of Statistical Results for Teams versus Individuals

Attribute	Teams N=9	Individuals N=16	Variances	P-value One tail t-test
Recognition of Dilemma	μ=2.33 v=2.25	μ=2.16 v=0.991	Equal	0.363
Information	μ=2.22 v=0.694	μ=2.56 v=0.299	Not Equal	0.142
Analysis	μ=2.16 v=0.375	μ=2.25 v=0.233	Equal	0.355
Perspective	μ=2.56 v=0.778	μ=2.50 v=0.500	Equal	0.423
Resolution	μ=2.17 v=0.875	μ=2.16 v=0.491	Equal	0.488
Overall score	μ=2.14 v=0.642	μ=2.28 v=0.399	Equal	0.314
Note: *μ range 1-5,* ***Boldface****=Confirmed at α = 0.10*				

5.4.2 Case 2: Report Quality for Ethics Teams versus Ethics Individuals

A summary of the statistical results comparing final resolution of student teams with engineering ethics training versus individuals with engineering ethics training is provided in Table 21.

When comparing mean scores, many of the original hypotheses were significantly disputed. The mean scores for Ethics Individuals were found to be higher for Information and Perspective and their Overall Score attributes. Relatively low scores of 1.6 and 2.21 for Recognition of Dilemma attribute, as well as for all other attributes, indicate that majority of both Ethics Teams and Ethics Individuals failed to recognize the ethical dilemma in this more complex case.

Table 21 Case 2 Report Quality: Summary of Statistical Results for Ethics Teams versus Ethics Individuals

Attribute	Ethics Teams N=5	Ethics Individuals N=7	Variances	P-value One tail t-test
Recognition of Dilemma	μ=1.6 v=0.800	μ=2.21 v=0.655	Equal	0.121
Information	μ=2.1 v=0.425	μ=2.86 v=0.060	Not Equal	**0.028**
Analysis	μ=2.2 v=0.325	μ=2.43 v=0.286	Equal	0.247
Perspective	μ=2.2 v=0.200	μ=2.71 v=0.238	Not Equal	**0.046**
Resolution	μ=1.8 v=0.450	μ=2.36 v=0.643	Not Equal	0.110
Overall score	μ=1.95 v=0.388	μ=2.46 v=0.300	Equal	**0.080**
Note: *μ range 1-5,* ***Boldface****=Confirmed at α = 0.10*				

5.4.3 Case 2: Report Quality for No Ethics Teams versus No Ethics Individuals

As Table 22 indicates there were no significant differences between No Ethics Teams and No Ethics Individuals. It is important to recognize that the majority of the no ethics subjects whether working in teams or as individuals failed to recognize the ethical dilemma. More often than not theses subjects chose to consider only an economic analysis path in their final resolution for this more complex case.

Table 22 Case 2 Report Quality: Summary of Statistical Results for No Ethics Teams versus No Ethics Individuals

Attribute	No Ethics Teams N=4	No Ethics Individuals N=9	Variances	P-value One tail t-test
Recognition of Dilemma	μ=2.25 v=2.25	μ=2.11 v=1.361	Equal	0.429
Information	μ=2.38 v=1.229	μ=2.33 v=0.250	Not Equal	0.473
Analysis	μ=2.13 v=0.563	μ=2.11 v=0.174	Equal	0.483
Perspective	μ=3 v=1.333	μ=2.33 v=0.688	Equal	0.129
Resolution	μ=2.63 v=1.229	μ=2 v=0.375	Equal	0.105
Overall score	μ=2.38 v=1.063	μ=2.14 v=0.470	Equal	0.315
Note: *μ range 1-5,* **Boldface***=Confirmed at α = 0.10*				

5.5 CASE 1 AND CASE 2 COMPARISONS USING REPORT QUALITY TOTAL SCORES

Descriptive statistics data comparing Case 1 and Case 2 reports for Ethics versus No Ethics and Teams versus Individuals together with the hypotheses test results are included in Table 23. As evidenced by the statistical results, Case 1 has higher mean scores than Case 2 for Ethics subjects, No Ethics subjects, Teams, Individuals and for all subjects together once again underlining the importance of the Case variable (moral intensity). And, as indicated in the prior sections, because the scores were significantly lower on Case 2 for all subjects factors into why there are no differences between students with engineering ethical training and those who have not had ethical training.

Table 23 Case 1 versus Case 2 Hypotheses for Total Score

Hypotheses	Case 1	Case 2	Variances	P-value One tail t-test
H1: *Total Score* for *Ethics* subjects for Case 1 > *Total Score* for Ethics subjects for Case 1	μ=19.08 v=4.40 N=12	μ=11.46 v=8.52 N=12	Not Equal	**0.0000**
H2: *Total Score* for *No Ethics* subjects for Case 1 > *Total Score* for *No Ethics* subjects for Case 2	μ=15.85 v=5.06 N=13	μ=11.35 v=14.47 N=13	Equal	**0.0006**
H3: *Total Score* for *Teams for* Case 1 > *Total Score* for *Teams* for Case 2	μ=17.88 v=7.04 N=9	μ=11.00 v=17.31 N=9	Equal	**0.0005**
H4: *Total Score* for *Individuals* for Case 1 > *Total Score* for *Individuals* for Case 2	μ=17.13 v=7.65 N=16	μ=11.63 v=8.45 N=16	Not Equal	**0.0000**
H5: *Total Score* for *All* subjects for Case 1 > *Total Score* for *All* subjects for Case 2	μ=17.40 v=7.27 N=25	μ=11.40 v=11.15 N=25	Not Equal	**0.0000**
Note: *μ range 5-25,* **Boldface***=Confirmed at α = 0.10*				

6.0 STATISTICAL TESTS FOR BEHAVIORAL OBSERVATIONS

As mentioned, both Teams and Individuals were video taped so that the processes they used to resolve the engineering ethical dilemmas could be evaluated. Table 4 (page 36) was used to denote what step/phase (aspect of the process) the person on team or individual was doing. The "time spent" on each attribute/category was recorded in "minutes." The first five categories correspond to the five categories in the PMEAR Rubric. Categories six through eight (Negative Impact/Not on Task, Waiting, and Do Not Know) were used for when the subjects did not work on solving the case and therefore they were not used in the analyses that follow.

As in the case of written reports, for each of the two cases and for each of the categories 1 thru 5 two sample F-tests for variances were conducted, and t-tests for means for "time spent" on categories 1 through 5 were performed to determine the following comparisons.

- Ethics versus No Ethics:
    1. Ethics subjects vs No Ethics subjects,
    2. Ethics Teams vs No Ethics Teams, and
    3. Ethics Individuals vs No Ethics Individuals.
- Teams versus Individuals:
    1. Teams versus Individuals,
    2. Ethics Teams vs Ethics Individuals, and
    3. No Ethics Teams vs No Ethics Individuals.

The list of hypotheses is provided in Table 24, Table 28, Table 32, and Table 36 followed by a detailed discussion of the results using statistical one tail t-tests with $\alpha = 0.10$.

6.1 CASE 1 BEHAVIORAL OBSERVATION: ETHICS VERSUS NO ETHICS COMPARISONS

The Ethics versus No Ethics hypotheses for Case 1 tested in this research are listed in Table 24 and the statistical results of the comparisons are analyzed in sections 6.1.1-6.1.3. For Case 1 we hypothesized that students who had training in engineering ethics would out perform (spent more time) than those without ethics training whether working in teams or as individuals.

As evidenced by the following results students with ethics consistently spent more time on Recognition of Dilemma (category 1) and Information (category 2) whether working in teams or individually.

Ethics Teams performed better (spent more time) than No Ethics Teams and Ethics subject performed better than No Ethics subjects when analyzing the problem from different perspectives, the aspects of problem solving process taught in ethics class.

Table 24 Case 1 Behavioral Observation: Hypotheses for Differences between Ethics and No Ethics

Hypotheses	**Ethics subjects vs No Ethics subjects**	**Ethics *Teams* vs No Ethics *Teams***	**Ethics *Individuals* vs No Ethics *Individuals***
H1 Time spent on Recognition of Dilemma	**E>NE**	**E>NE**	**E>NE**
H2 Time spent on Information	**E>NE**	**E>NE**	**E>NE**
H3 Time spent on Analysis	E>NE	E>NE	E>NE
H4 Time spent on Perspective	**E>NE**	**E>NE**	E>NE
H5 Time spent on Resolution	E>NE	E>NE	E>NE
Note: *E=Ethics, NE= No ethics,* **Boldface***=Confirmed at α = 0.10*			

6.1.1 Case 1 Behavioral Observation: Summary of Statistical Results for Ethics versus No Ethics Subjects

A summary of the statistical results for Ethics versus No Ethics for all subjects for behavioral observations for Case 1 is given in Table 25.

The time spent on Recognition of Dilemma, Information, and Perspective categories is greater for Ethics subjects than No Ethics subjects. This is possibly due to the fact that ethics students were trained to look for both known and unknown information and could be better prepared to recognize ethical issues and analyze the problem; from multiple perspectives, and hence spent more time on these categories.

For all the other attributes data could not statistically support that there is difference between ethics and no ethics subjects.

Table 25 Case 1 Behavioral Observation: Summary of Statistical Results for Ethics versus No Ethics Subjects (Time in Minutes)

Category/ Attribute	Ethics subjects N=22	No Ethics subjects N=21	Variance	P-value One tail t-test
1. Recognition of Dilemma	μ=1.199 v=1.536	μ=0.315 v=0.105	Not equal	**0.0017**
2. Information	μ=11.750 v=11.890	μ=8.557 v=5.627	Not equal	**0.0005**
3. Analysis	μ=14.937 v=26.267	μ=13.982 v=78.880	Equal	0.4338
4. Perspective	μ=0.7830 v=0.7997	μ=0.2529 v=0.0807	Not Equal	**0.0070**
5. Resolution	μ=13.0455 v=125.6362	μ=16.5831 v=221.6452	Not Equal	0.1930
Note: Boldface*=Confirmed at α = 0.10*				

6.1.2 Case 1 Behavioral Observation: Ethics Teams versus No Ethics Teams

Table 26 presents the statistical results for Ethics Teams versus No Ethics Teams for behavioral observations for Case 1. As evidenced by the data in Table 26 for three attributes: Recognition of Dilemma, Information, and Perspective, Ethics Teams performed better ("spent more time") in the solution process than the No Ethics Teams. As with the general differences between Ethics and No Ethics this is likely due to the training the team members received while taking ethics courses. Having a course in engineering ethics better prepares students to be more thorough in recognizing ethical dilemma, getting the necessary information, and discussing the situation from different perspectives utilizing more time to do so.

Table 26 Case 1 Behavioral Observation: Summary of Statistical Results for Ethics Teams versus No Ethics Teams (Time in Minutes)

Category/ Attribute	**Ethics *Teams* N=15**	**No Ethics *Teams* N=12**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=1.4429 v=2.0400	μ=0.2815 v=0.1306	Equal	**0.0056**
2. Information	μ=11.4177 v=8.4701	μ=7.7942 v=2.8565	Not equal	**0.0003**
3. Analysis	μ=17.2565 v=12.4855	μ=19.0541 v=49.849	Equal	0.198
4. Perspective	μ=1.0359 v=0.9441	μ=0.2763 v=0.0568	Not Equal	**0.0050**
5. Resolution	μ=7.9101 v=57.7447	μ=10.0127 v=89.9020	Not Equal	0.2695
Note: Boldface*=Confirmed at $\alpha = 0.10$*				

6.1.3 Case 1 Behavioral Observation: Ethics Individuals versus No Ethics Individuals

The statistical results for Ethics Individuals versus No Ethics Individuals for Behavioral Observations for Case 1 are summarized and presented in Table 27. As shown in Table 27 Ethics Individuals spent more time on Recognition of Dilemma and Information than No Ethics Individuals. As previously mentioned, this is perhaps due to the training provided by the ethics courses. Note, unlike the Ethics vs No Ethics and Ethics Teams vs No Ethics Teams, Perspective was not significantly different between Ethic Individuals and No Ethics Individuals.

Table 27 Case 1 Behavioral Observation: Summary of Statistical Results for Ethics Individuals versus No Ethics Individuals (Time in Minutes)

Category/ Attribute	Ethics *Individuals* N=7	No Ethics *Individuals* N=9	Variance	P-value One tail t-test
1. Recognition of Dilemma	μ=0.6769 v=0.1478	μ=0.3593 v=0.0798	Equal	**0.0385**
2. Information	μ=12.4610 v=20.9856	μ=9.5736 v=8.1048	Equal	**0.0715**
3. Analysis	μ=9.9651 v=20.5111	μ=7.2212 v=38.7051	Not Equal	0.1624
4. Perspective	μ=0.2411 v=0.0934	μ=0.2216 v=0.1219	Not Equal	0.4535
5. Resolution	μ=24.0501 v=97.7715	μ=25.3437 v=279.3989	Not Equal	0.4250
Note: Boldface*=Confirmed at α = 0.10*				

6.2 CASE 1 BEHAVIORAL OBSERVATION: TEAMS VERSUS INDIVIDUALS COMPARISONS

The "Teams versus Individuals" hypotheses tested in this research are listed in Table 28. The specific statistical results of the comparisons' are analyzed in sections 6.2.1-6.2.3. It was hypothesized that Teams would outperform Individuals on the "time spent" in each category.

In general, Teams are better than Individuals for the Recognition of Dilemma, Analysis, and Perspective categories. This maybe due to the fact that more discussion and points of view are presented by each member of the team; which, in turn, leads to better case dilemma recognition, information gathering and noticing different perspectives. As observed in the video tapes the whole team often tried to contribute to the process.

Similarly, Ethics Teams are better than Ethics Individuals for Recognition of Dilemma, Analysis, and Perspective categories. However for Resolution and Information the opposite was found to be true: Ethics Individuals spent more time than Ethics Teams.

When comparing No Ethics Teams with No Ethics Individuals, teams performed better in the Analysis category again confirming that teams can lead to better performance/longer discussion if no ethics training is involved.

In all three comparisons Individuals spent more time than Teams on the Resolution. This is perhaps due to the way the behavioral observations were coded. In a team setting Resolution (discussion and report typing time) is a single person category leading to a lower average for teams.

Table 28 Case 1 Behavioral Observation: Hypotheses of Differences between Teams and Individuals

Hypotheses	***Teams*' subjects vs *Individuals***	**Ethics *Teams* vs Ethics *Individuals***	**No Ethics *Teams* vs No Ethics *Individuals***
H1 Time spent on Recognition of Dilemma	**T>I**	**T>I**	T>I
H2 Time spent on Information	T>I	T>I	**T<I**
H3 Time spent on Analysis	**T>I**	**T>I**	**T>I**
H4 Time spent on Perspective	**T>I**	**T>I**	T>I
H5 Time spent on Resolution	**T<I**	**T<I**	**T<I**
Note: *T=Teams, I=Individuals,* **Boldface**= *confirmed at* $\alpha = 0.10$			

6.2.1 Case 1 Behavioral Observation: Teams' Members versus Individuals

A summary of the statistical results for Teams' subjects versus Individuals for Behavioral Observations for Case 1 is given in Table 29. The results for the "Recognition of Dilemma", Analysis and Perspective attributes show that there is a difference between Team members and Individuals. Teams spent more time on the Recognition of Dilemma. In case of Analysis and Perspective, Teams spent more time on this category compared to Individuals. One plausible explanation for this is that the contributions of the three team members facilitated more of discussion of the case in terms of analysis and enabled the teams to recognize more perspectives.

For "Resolution" Individuals spent more time perhaps due to the fact that writing the report was included in this category. In the case of Team's subjects only one team member typed the report while two others were then classified as doing something else (to other categories).

Table 29 Case 1 Behavioral Observation: Summary of Statistical Results for Teams' Members versus Individuals (Time in Minutes)

Category/ Attribute	***Team* members N=27**	***Individuals* N=16**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=0.9268 v=1.4997	μ=0.4983 v=0.1281	Not equal	**0.0492**
2. Information	μ=9.8072 v=9.1361	μ=10.8368 v=14.9053	Not equal	0.1846
3. Analysis	μ=18.0554 v=28.6228	μ=8.4217 v=30.8236	Not equal	**0.0000**
4. Perspective	μ=0.6983 v=0.6804	μ=0.2302 v=0.1025	Not Equal	**0.0061**
5. Resolution	μ=8.8445 v=70.2623	μ=24.7779 v=188.5606	Equal	**0.0000**
Note: Boldface*=Confirmed at α = 0.10*				

6.2.2 Case 1 Behavioral Observation: Ethics Teams versus Ethics Individuals

A summary of the statistical results for Ethics Teams versus Ethics Individuals are given in Table 30. In all categories, except for the Information and Resolution, Ethics Teams spent more time than Ethics Individuals on Case 1. The opposite was true for Resolution category.

Table 30 Case 1 Behavioral Observations: Summary of Statistical results for Ethics Teams vs Ethics Individuals (Time in Minutes)

Category/ Attribute	**Ethics *Teams'* members N=15**	**Ethics *Individuals* N=7**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=1.4429 v=2.0400	μ=0.6768 v=0.1479	Not Equal	**0.0346**
2. Information	μ=11.4178 v=8.4701	μ=12.4610 v=20.9856	Not equal	0.2978
3. Analysis	μ=17.2565 v=12.4855	μ=9.9651 v=20.5111	Not Equal	**0.0019**
4. Perspective	μ=1.0359 v=0.9441	μ=0.2411 v=0.0934	Not Equal	**0.0048**
5. Resolution	μ=7.9101 v=57.7447	μ=24.0501 v=97.7715	Not Equal	**0.0020**
Note: Boldface*=Confirmed at α = 0.10*				

6.2.3 Case 1 Behavioral Observation: No Ethics Teams versus No Ethics Individuals

A summary of the statistical results for No Ethics Teams versus No Ethics Individuals is given in Table 31. No Ethics Teams spent more time than No Ethics Individuals on Analysis. As each member usually takes part in a case discussion, in general teams tend to spend more time on this category than individuals. The opposite was true for Information and Resolution where No Ethics Individuals spent more time than No Ethics Teams. Again in case of Resolution this is likely due to the way the behavioral observations were coded. Resolution was a single person category resulting in a lower average for teams than in the case for individuals.

Note the relatively large variances for Resolution category when compared to variances of the other categories. This could be explained with a large range for "time spent" on Resolution data. There were a few cases when the subjects did not type a report at all (submitted handwritten one) or left for a computer lab to do the typing which resulted in a very small time for Resolution (minimum time of 1.52 minutes). On the other hand there were also a couple of subjects who took a very long time to produce the typed report (maximum time of 65.57 minutes). Note that both teams and individuals spent on average less than a minute on Recognition a rather short time. The same is true for Perspective. However in the case of Perspective the scoring rubric indicates this category is as a single person category that includes only the spent on *indicating* another perspective while the *discussion* of the different perspectives is coded as Analysis.

Table 31 Case 1 Behavioral Observations: Summary of Statistical results for No Ethics Teams versus No Ethics Individuals (Time in Minutes)

Category/ Attribute	**No Ethics *Teams'* members N=12**	**No Ethics *Individuals* N=9**	**Variance**	**P-value Two tail t-test**
1. Recognition of Dilemma	μ=0.2815 v=0.1306	μ=0.3593 v=0.0798	Equal	0.5994
2. Information	μ=7.7941 v=2.8565	μ=9.5736 v=8.1048	Not equal	0.1212
3. Analysis	μ=19.0541 v=49.8049	μ=7.2212 v=38.7051	Equal	**0.0008**
4. Perspective	v=0.2763 v=0.0568	μ=0.2217 v=0.1220	Not Equal	0.6524
5. Resolution	μ=10.0127 v=89.9019	μ=25.3438 v=279.3989	Equal	**0.0152**
Note: Boldface*=Confirmed at α = 0.10*				

6.3 CASE 2 BEHAVIORAL OBSERVATION: ETHICS VERSUS NO ETHICS COMPARISONS

Case 2 presents an ethical dilemma with a much higher Moral Intensity than Case 1 and it yields somewhat different results. The statistical results of the Ethics versus No Ethics hypotheses are listed in Table 32 and the detailed comparisons are analyzed in sections 6.3.1-6.3.3.

In all three comparisons Ethics Teams/Individuals performed better (spent more time) than No Ethics Teams/Individuals on Analysis only. It seems that ethics training results in subjects to spend more time analyzing the problem. Ethics subjects also spent more time on Information than No Ethics subjects. This is also true for Ethics Teams versus No Ethics Teams.

For all other categories the statistical data does not support the research hypotheses of Ethics performing better than No Ethics. It seems that at a higher level of moral intensity the majority of subjects, either working in Teams or as Individuals, overlooked ethical dilemmas in favor of analyzing the case from a monetary value point of view. These results are different for Case 1 where, in general, Ethics subjects performed better than No Ethics subjects for Recognition of Dilemma and Perspective.

Table 32 Case 2 Behavioral Observation: Hypotheses of Differences between Ethics and No Ethics

Hypotheses	**Ethics subjects vs No Ethics subjects**	**Ethics *Teams* vs No Ethics *Teams***	**Ethics vs No Ethics *Individuals* only**
H1 Time spent on Recognition of Dilemma	E>NE	E>NE	E>NE
H2 Time spent on Information	**E>NE**	**E>NE**	E>NE
H3 Time spent on Analysis	**E>NE**	**E>NE**	**E>NE**
H4 Time spent on Perspective	E>NE	E>NE	E>NE
H5 Time spent on Resolution	E>NE	E>NE	E>NE
Note: *E=Ethics, NE= No Ethics,* **Boldface***= confirmed at α = 0.10*			

6.3.1 Case 2 Behavioral Observation: Ethics Subjects versus No Ethics Subjects

A summary of the statistical results for Ethics versus No Ethics for all subjects for behavioral observations for Case 2 is given in Table 33.

Time spent on Information and Analysis categories is greater for Ethics subjects than for No Ethics subjects. As in the reports for Case 2 the results are somewhat counterintuitive. It seems Ethics subjects (either in teams and individuals) were waiting to do more analysis or being more complete in the analysis. Note the six minutes difference for mean time spent on Analysis for Ethics versus No Ethics subjects. Perhaps subjects with No Ethics having determined that there is no serious ethical dilemma did not feel the need to look for more Information and Analysis. Whereas students with formal engineering ethics training believe that they should be thorough in their work to provide further verification that there was no ethical dilemma.

For all the other attributes (Recognition of Dilemma, Perspective, and Resolution) statistical evidence does not support differences between Ethics and No Ethics subjects.

Table 33 Case 2 Behavioral Observation: Summary of Statistical Results for Ethics versus No Ethics Subjects (Time in Minutes)

Category/ Attribute	**Ethics subjects N=22**	**No Ethics subjects N=21**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=0.3992 v=0.1399	μ=0.5135 v=0.3645	Equal	0.2286
2. Information	μ=19.5701 v=17.3473	μ=17.2020 v=30.1820	Not Equal	**0.0604**
3. Analysis	μ=17.4328 v=85.5111	μ=11.4942 v=49.1531	Equal	**0.0114**
4. Perspective	μ=0.1718 v=0.0492	μ=0.2262 v=0.0899	Not Equal	0.2521
5. Resolution	μ=11.3799 v=130.9247	μ=10.4729 v=0.063	Not Equal	0.4003
Note: Boldface=*Confirmed at α = 0.10*				

6.3.2 Case 2 Behavioral Observation: Ethics versus No Ethics Team Members Only

A summary of the statistical results for Ethics Teams versus No Ethics Teams for the behavioral observations for Case 2 is given in Table 34. As evidenced by the data in Table 34 the “time spent” on Information and Analysis is larger for Ethics Teams than No Ethics Teams. This is similar to the general case of Ethics vs. No Ethics presented in the prior section 3.3.1 and likely due to the fact that obtaining proper information and careful analysis of the information is taught in ethics courses.

Table 34 Case 2 Behavioral Observations: Summary of Statistical Results for Ethics Teams versus No Ethics Teams (Time in Minutes)

Category/ Attribute	**Ethics *Teams* N=15**	**No Ethics *Teams* N=12**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=0.3069 v=0.0553	μ=0.3241 v=0.1253	Not equal	0.4430
2. Information	μ=19.1857 v=11.2868	μ=16.7146 v=32.8220	Equal	0.0869
3. Analysis	μ=19.4011 v=93.0959	μ=14.3338 v=39.9362	Equal	**0.0648**
4. Perspective	μ=0.1967 v=0.0475	μ=0.2425 v=0.0705	Not Equal	0.3172
5. Resolution	μ=5.6439 v=52.6782	μ=5.4697 v=37.5953	Equal	0.4738
Note: Boldface*=Confirmed at α = 0.10*				

6.3.3 Case 2 Behavioral Observation: Ethics Individuals versus No Ethics Individuals

Summary of statistical results for Ethics Individuals versus No Ethics Individuals for behavioral observations for Case 2 is given in Table 35. Data in Table 35 shows that Ethics Individuals spent more time on Analysis than No Ethics Individuals. It seems that ethics training stresses the importance of being thorough in analyzing the case.

In case of higher moral intensity ethical dilemmas (like Case 2) subjects with Ethics were not able to perform better for other categories. Case 2 dealt with car racing and in quite a few instances the possibility of a loss of life of the driver was seen as “an occupational hazard,” not an ethical dilemma for the management and therefore not warranting further discussion for Recognition of Dilemma or for Perspective.

Table 35 Case 2 Behavioral Observation: Summary of Statistical Results for Ethics Individuals versus No Ethics Individuals (Time in Minutes)

Category/ Attribute	**Ethics *Individuals* N=7**	**No Ethics *Individuals* N=9**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=0.5971 v=0.2936	μ=0.7662 v=0.6135	Not Equal	0.3092
2. Information	μ=20.3938 v=33.2187	μ=17.8521 v=29.4930	Equal	0.1905
3. Analysis	μ=13.2150 v=51.6246	μ=7.7082 v=39.7501	Equal	0.0624
4. Perspective	μ=0.1186 v=0.0567	μ=0.2046 v=0.1269	Not Equal	0.2865
5. Resolution	μ=23.6714 v=76.80	μ=17.1438 v=216.4383	Not Equal	0.1450
Note: Boldface*=Confirmed at $\alpha = 0.10$*				

6.4 CASE 2 BEHAVIORAL OBSERVATION: TEAMS VERSUS INDIVIDUALS COMPARISONS

Hypotheses testing for differences between Teams vs. Individuals for Case 2 are listed in Table 36. The statistical results of the comparisons were then analyzed in sections 6.4.1-6.4.3. It was expected that Teams would spend more time than Individuals on all behavioral observation categories. The results were not realized in all but one category.

In two of the three comparisons the statistical results show that Teams spent more time than Individuals on Analysis only. This is likely due to the fact that more discussion and points of view were presented in a team setting leading to longer problem discussion time. The opposite was true for Recognition of Dilemma and Resolution categories. This could be attributed to the fact that both of these categories are single person categories and in a team setting the time spent on Recognition and Resolution was averaged over three team members.

Table 36 Case 2 Behavioral Observation: Hypotheses of Differences between Teams and Individuals

Hypotheses	***Teams'* members vs *Individuals***	**Ethics Teams vs Ethics *Individuals***	**Direction No Ethics Teams vs No Ethics Individuals**
H1 Time spent on Recognition of Dilemma	**T<I**	**T<I**	**T<I**
H2 Time spent on Information	T>I	T>I	T>I
H3 Time spent on Analysis	**T>I**	**T>I**	**T>I**
H4 Time spent on Perspective	T>I	T>I	T>I
H5 Time spent on Resolution	**T<I**	**T<I**	**T<I**
***Note**: T=Teams, I=Individuals, **Boldface**= confirmed at α = 0.10*			

6.4.1 Case 2 Behavioral Observation: Teams' Members versus Individuals (All Subjects)

A summary of the statistical results for Teams' subjects versus Individuals for behavioral observations for Case 2 is given in Table 37.

The results for the Recognition of Dilemma and Resolution attributes show that there is a difference between Team members and Individuals with team members spending less time on this category. This was perhaps due to the fact that both of these categories were defined as a single person category which in turn lowered the average for Teams.

In case of Analysis, Team members spent more time on this category compared to Individuals. Perhaps the team approach facilitated more of a discussion in terms of case Analysis. Note that there is a seven minute difference for Analysis with teams spending significantly more time on Analysis as working in teams facilitates more discussion. On the other hand, in case of Resolution Individuals spent significantly more time than Teams. This result may be explained by the coding procedure. For Individuals typing of the report was included in the Resolution. Whereas, in case of teams while one person writing/typing the report was coded as Resolution and the other two team members were coded as either Waiting or Not on Task or doing Analysis lowering team's average time on Resolution.

Table 37 Case 2 Behavioral Observation: Summary of Statistical Results for Teams' Members versus Individuals (Time in Minutes)

Category/ Attribute	***Team* members N=27**	***Individuals* N=16**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=0.3145 v=0.0828	μ=0.6922 v=0.4521	Equal	**0.0070**
2. Information	μ=18.0873 v=21.5294	μ=18.9641 v=30.7129	Not Equal	0.2996
3. Analysis	μ=17.1489 v=73.6086	μ=10.1174 v=49.8100	Equal	**0.0042**
4. Perspective	μ=0.2170 v=0.0559	μ=0.1669 v=0.0923	Not Equal	0.2880
5. Resolution	μ=5.5664 v=44.2787	μ=19.9996 v=157.3405	Equal	**0.0000**
Note: Boldface*=Confirmed at α = 0.10*				

6.4.2 Case 2 Behavioral Observation: Ethics Teams versus Ethics Individuals

Statistical results for Ethics Teams versus Ethics Individuals comparisons for behavioral observations for Case 2 are presented in Table 38.

The results show that Ethics Individuals spent more time on Recognition of Dilemma and Resolution. This is perhaps due to the fact that Recognition and Resolution were single subject categories. In case of teams this lowered the teams' average time spent on Recognition of dilemma and Perspective. These results are different from Case 1 findings where Teams spent more time on Recognition of Dilemma and on Perspective. It seems that in case of lower moral intensity (Case 1) ethics training provides students with an ability to better detect the ethical dilemma and, in turn, discuss the problem from various perspectives. With the higher moral intensity case (Case 2) the teams appear to either "followed the leader" and in several instances focus primarily on an economic analysis as the solution to the problem. Individuals, on the hand, spent more time on Recognition of Dilemma.

Ethics Teams spent more time that than Ethics Individuals on Analysis as team setting lends itself to longer exchange of ideas and points of view.

Table 38 Case 2 Behavioral Observation: Summary of Statistical results for Ethics Teams vs Ethics Individuals (Time in Minutes)

Category/ Attribute	**Ethics *Teams'* members N=15**	**Ethics *Individuals* N=7**	**Variance**	**P-value Two tail t-test**
1. Recognition of Dilemma	μ=0.3069 v=0.00652	μ=0.5971 v=0.2936	Equal	**0.0900**
2. Information	μ=19.1857 v=11.2867	μ=20.3938 v=33.2187	Equal	0.5392
3. Analysis	μ=19.4011 v=93.0959	μ=13.215 v=51.6246	Equal	0.1478
4. Perspective	μ=0.1967 v=0.0475	μ=0.1186 v=0.0567	Not Equal	0.4772
5. Resolution	μ=5.6439 v=52.6782	μ=23.6714 v=76.8037	Not Equal	**0.0008**
Note: Boldface*=Confirmed at α = 0.10*				

6.4.3 Case 2 Behavioral Observation: No Ethics Teams versus No Ethics Individuals

Table 39 provides a summary of the statistical comparisons of No Ethics Teams vs No Ethics Individuals. As with the prior two analyses, the statistical tests show that No Ethics Teams spent less time on Recognition of Dilemma and Resolution categories. This is likely due to the coding approach as mentioned in the previous section. Ethics Teams spent more time on Analysis. In a team setting more time is spent analyzing the problem than in the case of an Individual problem solving the dilemma.

Table 39 Case 2 Behavioral Observation: Summary of Statistical Results for No Ethics Teams vs No Ethics Individuals (Time in Minutes)

Category/ Attribute	**No Ethics *Teams'* N=12**	**No Ethics *Individuals* N=9**	**Variance**	**P-value One tail t-test**
1. Recognition of Dilemma	μ=0.3241 v=0.01252	μ=0.7662 v=0.6135	Equal	**0.0487**
2. Information	μ=16.7145 v=32.8220	μ=17.8521 v=29.4930	Not Equal	0.324
3. Analysis	μ=14.3338 v=39.9361	μ=7.7082 v=39.7500	Equal	**0.0139**
4. Perspective	μ=0.2426 v=0.0705	μ=0.2046 v=0.1269	Not Equal	0.3959
5. Resolution	μ=5.4697 v=37.5953	μ=17.1438 v=0.055	Equal	**0.0111**
Note: Boldface*=Confirmed at $\alpha = 0.10$*				

7.0 PROFESSIONAL DEVELOPER DATA ANALYSIS

The Professional Developer instrument was used to measure teamwork (McGourty and De Meuse, 2000). Study participants who worked in teams evaluated themselves and their team members with respect to: decision-making, collaboration, communication, and self-management on a scale 1 to 5 (1 being “never“….. and 5 being “always“). A two-sample F-test for variances indicated that the variances were not equal for all four categories. Subsequently, the appropriate two-sample t-tests for means were conducted.

The statistical test results are summarized in Table 40. The results showed that students trained in engineering ethics perform significantly better than students not trained in engineering ethics in two of the categories: decision making and collaboration. This is perhaps due to the fact that engineering students who are trained in ethical decision reasoning are better equipped to work collaboratively with others in addressing engineering ethics situations and tasks. In addition, their approach to decision making has been enhanced for ethics-based analyses as well as approaching the problem from different perspectives. Whereas students who did not have engineering ethics training although may be good team members, are not as equipped as their “engineering ethics” counterparts given the task provided to them.

Table 40 Team Developer Results for "Others" Evaluation

Attribute	**Ethics N=15**	**No Ethics N=12**	**P-value One tail t-test**
Collaboration	μ=4.22 v=0.11	μ=3.91 v=0.20	**0.028**
Decision-Making	μ=3.89 v=0.14	μ=3.63 v=.19	**0.060**
Communication	μ=3.91 v=0.08	μ=3.78 v=0.17	0.354
Self-Management	μ=3.72 v=0.21	μ=3.62 v=0.38	0.654
Note: Boldface *= Confirmed at α = 0.10*			

8.0 REGRESSION MODELS

In this research a conceptual model for ethical decision making in engineering was developed (see Figure 4, p.26). Aspects of the Jones's factors as well as the Harris, Pritchard and Rabins (HPR) process variables were captured and considered as independent variables that potentially influence the quality of the proposed resolution (the score on the final Resolution report). In addition, the times spent on behavioral observation categories as defined in Table 4 (p.36) were included as potential influencers of a quality resolution. These related to the various process variables in the HPR's normative model. Correlation and regression analyses were employed to detect those independent variables in the conceptual model augmented by the behavioral observation categories that are significant with respect to the "quality" of the solution.

In this chapter we present three general regression models. The purpose of the regression models is to determine those variables that best account for the variation in the resolution. The first model provides the most influential variables in predicting the resolution for Case 1. The second model provides similar information, but for Case 2. For the third model, Case, a surrogate measure for moral intensity, becomes an independent variable.

8.1 INDEPENDENT VARIABLES IN THE REGRESSION MODEL

Because there were many "potential" independent variables, the set of independent variables was established by evaluating the correlations between all possible variables measured in this experiment based on the conceptual model. From the correlation analysis, the set of independent variables to be included is described in Table 41.

Table 41 Independent Variables in the Regression Model

Variable name	Units	Range of Values
Work experience	Years	0-3.25
Gender	Male or Female	1 or 0
Age	Years	21-35
Major	IE, CE, BioE	Coded as Dummy Variables D1, D2
Total credits	Total number of college credits	124-167
Engineering credits	Number of engineering credits	85-120
Ethics class	Yes or No	1 or 0
Team/Individual	Team or Individual	1 or 0
Total Self-Efficacy score (SEF)		4-20
P-score from DIT	In percent based on DIT score	10-50
Time spent on behavioral observation (BO) categories (1-Recognition of Dilemma, 2-Information, 3-Analysis, 4-Perspective, and 5-Resolution).	Minutes	0.000-65.600
Case number	Case1 or Case 2	1 or 0

8.2 REGRESSION MODEL FOR THE QUALITY OF THE RESOLUTION

As mentioned, three separate models were developed as the magnitude of the contributions as measured by the coefficient of determination for the Case variable was fairly high (see Table 45, p. 93):

(1) Case 1 Model (using data for Case 1)

(2) Case 2 Model (using data for Case 2)

(3) Combined Model (using data for both cases and Case variable).

For each model, seven stepwise regression models (Models A-G) were conducted. The response variable was the score from each category of the PMEAR rubric (Attributes 1-5/ Models A-E), one for the Overall Score (Model F), and a one for the Total Score (sum total of scores for categories 1 through 5, Model G). However, particular attention is given to Models F and G. All statistically significant variables from the correlation analyses were used as independent variables, as provided in the Table 42. Results of the regression analyses for the three sets of models are presented in sections 8.2.1-8.2.3. Dependent variables for each of the seven stepwise regression models are defined in Table 42.

Table 42 Dependent Variables in the Regression Models

Model name	Dependent Variable
Model A	Score for Recognition of Dilemma
Model B	Score for Information
Model C	Score for Analysis
Model D	Score for Perspective
Model E	Score for Resolution
Model F	Overall Score
Model G	Total Score (sum of scores for Models A-E)

8.2.1 Case 1 Regression Models

Results of the regression analyses for the Case 1 regression models are presented in Table 43. The coefficients of multiple determination (*R-square*) for the models range from 0.384 to 0.516. The variable with the highest contribution came from Ethics Class variable. This variable was found to be a significant predictor for all models accounting for 13 to 38.9 percent of the total variation (average of 25.13 percent).

In Model G, the *R-square* was 0.493. It consisted of four variables as follows.

1. Whether or not a student had engineering ethics (Ethics Class variable) accounted for 30.3 percent of the variation.
2. The dummy variable, D2-Major, accounted for 8.3 percent of variation showing that bioengineering subjects (BioE) performed significantly better (positive coefficient) than industrial engineering (IE) and civil engineering (CE) subjects.
3. Time spent on Perspective (BO cat-4) accounted for 6.4 percent of the variation with a negative sign on the coefficient indicating "less" time spent on Perspective contributed to a higher total score.
4. Being on a Team accounted for 4.3 percent of variation.

In Model F, the Overall Score Model the *R-square* was 0.487 and the same variables are found to be significant for this model as for Model G with similar explained variation.

In the other models (Models A-E), Work Experience and SEF score variables were significant predictors of Model B (score for Information) accounting roughly for four percent each, while P-score (DIT) variable was a significant predictor of Model A (score for Recognition) accounting for seven percent of variation. For behavioral observation variables, "less" time spent on Perspective (BO cat-4) was a significant predictor of Model B (Information) and Model D (Perspective) accounting for 7.4 percent and 12.2 percent respectively. Time spent on Resolution (BO cat-5) was a significant predictor for Model E (Resolution).

Table 43 Regression Model for Case 1

Independent variable	**Model A Recognition of Dilemma**	**Model B Information**	**Model C Analysis**	**Model D Perspective**	**Model E Resolution**	**Model F Overall Score**	**Model G Total Score**
Constant (intercept) β_0	β_0=2.782	β_0=3.127	β_0=3.140	β_0=3.238	β_0=2.780	**β_0=2.872**	**β_0=15.157**
Work Experience		R^2=.038 β_1=.131					
D1-Major			R^2=.095 β_1= -.377				
D2-major		R^2=.268 β_1=.725			R^2=.055 β_1=.261	**R^2=.148** **β_1=.530**	**R^2=.083** **β_1=1.911**
Ethics Class	R^2=.389 β_1=.627	R^2=.168 β_1=.538	R^2=.215 β_1=.730	R^2=.315 β_1=.603	R^2=.130 β_1=.421	**R^2=.239** **β_1=.373**	**R^2=.303** **β_1=3.268**
Team/Individual					R^2=.093 β_1=.691	**R^2=.060** **β_1=.556**	**R^2=.043** **β_1=1.183**
SEF		R^2=.042 β_1= -.041					
P-score (DIT)	R^2=.071 β_1=.010						
BO-cat 2	R^2=. 049 β_1=. 048						
BO-cat 4			R^2=.074 β_1= -.268		R^2=. 122 β_1=-.411	**R^2=. 040** **β_1= -.185**	**R^2=. 064** **β_1= -1.295**
BO-cat 5					R^2=. 065 β_1=.012		
Total	**R^2=.509**	**R^2=.516**	**R^2=.384**	**R^2=.315**	**R^2=.465**	**R^2=.487**	**R^2=.493**
Total Adjusted R^2	**.472**	**.465**	**.337**	**.298**	**.392**	**.432**	**.439**

8.2.2 Case 2 Regression Models

Results of the regression analyses for Case 2 regression models are presented in Table 44. The *R-square* values for the models are interestingly much higher than for Case 1 ranging from 0.594 to 0.799. Work Experience, Major, and time spent on analysis (BO cat-3) variables were significant predictors for all seven models, while being female (Gender) was a significant predictor for all models except Model B (score for Information). The highest contribution across all models came from a student major (D1 Major) variable showing that industrial engineering subjects contributed "less" and performed significantly different than bioengineering and civil engineering subjects.

In Model G, Total Score model, the *R-square* value was 0.628 and consisted of five variables. The highest contribution, 20.4 percent, came from the D1 Major variable showing industrial engineering subjects contributing significantly "less" to the final resolution than bioengineering and civil engineering subjects. Having had an engineering ethics course (Ethics Class) accounted for 13.8 percent of the variation. Time spent on analysis (BO-Cat 3) accounted 12.1 percent of the variation. Work experience accounted for 8.6 percent of the variation while Gender accounted for 7.9 percent of the variation.

The *R-square* for Model F, the Overall Score Model, was 0.692 and consisted of the same number of significant variables as for Model G with similar explained variation. Here both D1 Major and D2 Major variables show that industrial engineering and bioengineering subjects contributed "less" and performed significantly different than civil engineering subjects.

Table 44 Regression Model for Case 2

Independent variable	**Model A Recognition of Dilemma**	**Model B Information**	**Model C Analysis**	**Model D Perspective**	**Model E Resolution**	**Model F Overall Score**	**Model G Total Score**
Constant (intercept) β_0	β_0=-0.652	β_0=.979	β_0=1.769	β_0=5.634	β_0=1.748	**β_0=2.393**	**β_0=11.048**
Work Experience	R^2=.216 β_1=.293	R^2=.109 β_1=.248	R^2=.027 β_1=.115	R^2=.164 β_1=.213	R^2=.166 β_1=.247	**R^2=.209** **β_1=.232**	**R^2=.086** **β_1=1.058**
Gender	R^2=.070 β_1=-1.138		R^2=.112 β_1= -.320	R^2=.096 β_1= -.498	R^2=.085 β_1= -.555	**R^2=.134** **β_1= - .737**	**R^2=.079** **β_1= -3.241**
Age	R^2=.043 β_1=-.126						
D1-Major	R^2=.096 β_1=-.822	R^2=.269 β_1=-.405	R^2=.254 β_1= -.575	R^2=.067 β_1= -.997	R^2=.072 β_1= -.564	**R^2=.086** **β_1=-.767**	**R^2=.204** **β_1=-3.276**
D2-Major		R^2=.065 β_1=.481		R^2=.073 β_1= -.546		**R^2=.030** **β_1= -.323**	
Total Credits				R^2=.048 β_1= -.021			
Ethics Class	R^2=.070 β_1=-.1.188			R^2=.087 β_1= -.811	R^2=.111 β_1=-.810	**R^2=.135** **β_1=-.609**	**R^2=.138** **β_1=-3.170**
Team/ Individual			R^2=.017 β_1=-.179				
P-score (DIT)		R^2=.064 β_1=.014	R^2=.040 β_1=.007		R^2=.082 β_1=.011		
BO-cat 3	R^2=.143 β_1=.068	R^2=.083 β_1=.025	R^2=.280 β_1=.032	R^2=.059 β_1=.047	R^2=.086 β_1=.047	**R^2=.098** **β_1=.041**	**R^2=.121** **β_1=.218**
BO-cat 4			R^2=.069 β_1=.447				
BO-cat 5		R^2=.096 β_1=.024					
Total	**R^2=.638**	**R^2=.686**	**R^2=.799**	**R^2=.594**	**R^2=.602**	**R^2=.692**	**R^2=.628**
Total Adjusted R^2	**.577**	**.634**	**.759**	**.513**	**.536**	**.641**	**.578**

8.2.3 Regression Analysis for the Combined Model

Results for the combined regression models are presented in Table 45. The *R-square* values for the models ranged from 0.395 to 0.71. Given the nature of the data (primarily qualitative behavioral data) and the small sample sizes the results are promising.

Not surprisingly, the highest contribution across all models came from Case variable and ranged from 36.3 to 54.1 percent (average of 46.2 percent). Work Experience was a significant predictor of all models except Model C (score for Analysis), while Gender was a significant predictor for five of the seven models. The dummy variable Major (Major-D1, Major- D2) was a significant predictor in six of the models.

In Model G (Total Score Model) the *R -square* value was 0.661 and it consisted of five variables. The Case variable accounted for 51.8 percent of the variation. The D1-major followed and accounted for 6.0 percent of variation and showed that industrial engineering subjects contributed significantly "less" (negative coefficient) than civil engineering and bioengineering subjects. The Gender variable accounted for 3.3 percent, and the BO-Cat 3 (time spent on Analysis) accounted for 3.1 percent of the known variation while Work Experience accounted for roughly two percent.

In Model F (the Overall Score Model) similar results were obtained with the total *R-square* of 0.663. In addition, more time spent on Perspective (BO-cat.4 variable) accounted for roughly two percent of the variation.

Table 45 General Regression Model

Independent variable	**Model A Recognition of Dilemma**	**Model B Information**	**Model C Analysis**	**Model D Perspective**	**Model E Resolution**	**Model F Overall Score**	**Model G Total Score**
Constant (intercept) β_0	β_0= 1.244	β_0= 1.580	β_0=2.174	β_0= 2.365	β_0=3.921	**β_0= 2.092**	**β_0=10.580**
Work Experience	R^2=. 046 β_1=.263	R^2=.048 β_1=. 231		R^2=.032 β_1=.143	R^2=.053 β_1=.153	**R^2=.022 β_1=. 138**	**R^2=. 019 β_1=.630**
Gender	R^2=. 047 β_1= -.336		R^2=. 046 β_1 =-.342		R^2=.027 β_1= -.381	**R^2=.031 β_1=-.394**	**R^2=. 033 β_1=-1.822**
D1-major	R^2=.015 β_1= -.398		R^2=.092 β_1=-.540		R^2=.021 β_1=-.463	**R^2=.054 β_1=-.400**	**R^2= .060 β_1 =-2.123**
D2-major		R^2=.140 β_1=. 736					
Total Credits					R^2=. 013 β_1 =-.013		
Ethics Class		R^2=. 019 β_1=.259			R^2=. 018 β_1= -.313		
SEF	R^2=.011 β_1= -.040	R^2= .027 β_1=-.036					
P-score (DIT)	R^2=.017 β_1= .013	R^2=. 030 β_1=. 010					
Case	R^2=. 541 β_1= 2.056	R^2=.387 β_1= 1.079	R^2=.432 β_1=1.037	R^2=.363 β_1= 1.012	R^2=.485 β_1= 1.327	**R^2=.508 β_1= 1.234**	**R^2= .518 β_1=6.564**
BO-cat-2	R^2=. 012 β_1=.035						
BO-cat 3			R^2=.058 β_1=.027		R^2=.021 β_1=. 027	**R^2=.031 β_1=.016**	**R^2=. 031 β_1=. 096**
BO-cat 4	R^2=. 021 β_1= .364					**R^2=.017 β_1=.230**	
BO-cat 5		R^2= .017 β_1=.010					
Total R^2	**R^2=. 710**	**R^2=. 668**	**R^2=. 628**	**R^2=.395**	**R^2=.638**	**R^2=.663**	**R^2=.661**
Total Adjusted R^2	**.680**	**. 638**	**.610**	**.381**	**. 606**	**. .637**	**.640**

In summary, for a case with lower moral intensity decisions (Case 1) having an ethics class does prove to be influential in producing good resolutions to ethical dilemmas. For cases of higher moral intensity decisions (Case 2), Work Experience was the critical variable as only few of the subjects (Teams/Individuals or Ethics/No Ethics) recognized the ethical dilemma. The fact that the level of moral intensity is a critical variable was confirmed by the results of the third set of models (Table 45).

9.0 OVERREACHING FINDINGS AND CONTRIBUTION

The major contribution of this research effort is twofold. First, an ethical decision making model for engineering with consideration for teamwork was developed; and second, this model was to a certain extent evaluated across two cases involving decisions of different levels of moral intensity. From this research, the analysis of the group decision making process and its outcomes has enabled the researcher to identify key factors that play a role in engineering ethical decision making, identify potential improvement areas in the process of resolving an ethical engineering dilemma, as well as areas where pedagogy can have the greatest impact.

Comparing groups of students (those with training in engineering ethics versus those without training) provides an understanding about the degree to which a course in engineering ethics improves the ability to resolve ethical issues and the quality of the resolution reached by engineers when posed with an ethical dilemma; and hence an improved understanding of professional and ethical responsibility. Indirectly, the results of this research effort aid pedagogy by determining which areas of the decision making process to emphasize when teaching engineering ethics. In particular, data shows that Case 2, the more complex case (one wit a higher moral intensity) was not recognized as an ethical issue and hence could not be resolved correctly by the participants resulting in lower scores across all the attributes. Admittedly many of the subjects (both teams and individuals) brought up the issue of informed consent of the race car driver about the dangers of driving under the unsafe conditions. Yet this issue was taken that the driver is always aware of the dangers. Although the students recognized the importance of informed consent in ethics, they did not see it was important that the driver be aware of each danger that might come about as in this case. These findings suggest that perhaps more emphasis should be placed during class case discussions to make students more sensitive to detecting the variety of ethical dilemmas and the underlying aspects across multiple levels of moral intensity.

From our analysis of the Combined Regression Model it was shown that moral intensity as measured by the surrogate Case variable plays a significant role as to how students are able to resolve engineering ethical dilemmas, as it accounts for the majority of the variation in the model.

For situations involving lower moral intensity decisions (Case 1) we found that knowing engineering ethics is critical for engineering students as the students with engineering ethics training consistently performed better than students without ethics training in all categories, whether working in teams or individually. When working in teams, students with ethics are able to recognize the ethical dilemma and analyze the problem from various perspectives better than students without ethics training. However, Ethics Teams did not satisfactorily differ from Ethics Individuals for any category, which may not be surprising as all subjects had training in engineering ethics. Whether trained or not in engineering ethics, in general, Teams performed better than Individuals for an important category, Resolution.

Additionally as shown by the behavioral observation students trained in ethics spent more time on their case than did students with no ethics training. Subjects with ethics training, whether working in Teams or as Individuals, spent more time on Recognition of ethical dilemma and Information. In addition for Perspective, Ethics subjects performed better (i.e., spent more time) than No Ethics subjects; and Ethics Teams performed better than No Ethics Teams. Teams in general spent more time than Individuals on Analysis. However the opposite was true for Resolution primarily due to the way the behavioral observations were coded. For two categories, Recognition of Dilemma and Perspective, Teams spent more time than Individuals and Ethics Teams spent more time than Ethics Individuals as perhaps more discussion and points of view had to be considered in a team setting.

However as the moral intensity increased (Case 2) we found that overall there were no differences between students who had engineering ethics versus those who did not. For Teams, there were no statistical differences between Ethics Teams and No Ethics Teams; and in addition, for Perspective the hypothesis proved to be in the opposite direction than intended (No Ethics Teams were better than Ethics Teams). When comparing individuals, Ethics Individuals performed better than No Ethics Individuals in Information and Analysis only; and contrary to what was hypothesized, Ethics Individuals performed better than Ethics Teams for Information, Perspective and Overall Score categories. Only for Resolution did Ethics Teams perform statistically better than Ethics Individuals.

For Case 2, the case of higher moral intensity, in general and not surprisingly, Ethics students spent more time on Analysis than No Ethics students whether working in Teams or as Individuals.

In summary for cases with decisions requiring lower levels of Moral Intensity (as in Case 1) it is likely that Teams will perform better and training in engineering ethics will plausibly lead to a better resolution of ethical dilemmas.

Regression analysis models using the data for the two cases studied provide a number of important variables to the ethical dilemma resolution quality and the quality of the solution process categories. The derived models show that having had an ethics course, working in teams, having work experience, being female, and the type of engineering major, as well as the moral intensity of the ethical decision are significant predictors of the overall Resolution as measured by the report quality.

This in itself may not be surprising but this research provides confirmation of results on the value of teams and education in engineering ethics. In addition exogenous factors such as work experience and gender also influence the quality of resolution. However, with that said, much applied research is needed to consider how issues of higher moral intensity can be better incorporated into the teaching of engineering ethics. In the second case, students often indicated that the drivers knew the danger of car racing; but this was also true for the Challenger astronauts of which the Case 2 is modeled after.

In this research a complete overarching conceptual model for engineering ethical decision making is developed. With literature-based measurable variables that are grouped into the following categories: Problem Characteristics, Individual Attributes, Team Characteristics, Professional and Legal Environment, and Personal Environment categories (as shown in Figure 4, page 26). Of those variables, many were included in the empirical study and subsequent regression models; however, some that were not relative to the specific subject pool were impractical and thus not used. In the empirical study Moral Intensity was used to describe the Problem Characteristic. For Individual Attributes Cognitive Moral Development (P-score on DIT) was used, as well as, Ethical Self-Efficacy, Knowledge and Demographics. Team Characteristics was included in this study using the results of the Professional Developer for team workability and the number of total engineering credits served as data for the level of Professional Knowledge (and whether or not the team was versed in engineering ethics).

Unfortunately, aspects of the Professional/Legal Environment were never brought up in student discussions in terms of codes: only light references to codes were mentioned by a few teams and theses were from civil engineers. The Personal Environment category was not used as the data was not relevant to the subjects used.

This study shows the value of an engineering ethics education in resolving ethical dilemmas even if such dilemmas are of a lower moral intensity level; and coupled to this is the value of teamwork in resolving ethical dilemmas. However, what might be needed for the future engineering education curricula is to involve additional group training with cases involving a higher moral intensity domain, as the Problem Characteristics highly impact the quality of the resolution. This certainly seems to be the case for the two engineering ethics courses involved in this study. To sum, investigating group moral decision-making has particular significance beyond professional standards and educational accreditation. Moral decision making has potential profitable returns for organizations. A study conducted by Rutgers University found that investors in firms that fostered an ethical work environment realized an annual shareholder rate of return roughly 45 percent higher than firms that ignored ethics (Kurschner, 1996). A study conducted by Verschoor (1998) found "a statistically significant linkage between a management commitment to strong controls that emphasize ethical and socially responsible behavior on one hand and favorable financial performance on the other".

10.0 FUTURE RESEARCH

During this dissertation research, the differences between Teams and Individuals, Ethics and No Ethics, when solving engineering ethics dilemmas using two cases with different moral intensity level were investigated. In addition, the association of a number of variables with the Quality of Resolution was examined. Several areas of future work that have been identified and are now discussed.

First, in this study two case studies with different moral intensity levels were used; one with low moral intensity (Case 1) and one with a higher moral intensity level (Case 2) as evaluated by the researchers. As evidenced by the statistical results presented in Chapters 6 - 8 the conclusions are considerably different for the two cases. Future research should be to replicate a similar study utilizing additional cases along a continuum of moral intensity levels from low (similar to Case 1) to reasonably high (as presented in Case 2). Such research should attempt to detect areas of improvement for pedagogy in a more specific way providing more insight as to which steps in the resolution process need greater pedagogical detail. As seen from this particular research, having an engineering ethics education clearly made an impact with regards to recognizing and resolving Case 1, but appeared to have at best minimal impact for Case 2. The only subject that performed well on Case 2 was a non-traditional older student with solid work experience and who had the engineering ethics course. . Further, the use of the moral intensity scale in this research was based on two engineering ethics experts evaluating the two different cases. In prior research (Goles, White, Bebee, Dorantes, and Hewitt: 2006), moral intensity was evaluated by the students. A comparison between the students' and experts' perception of the moral intensity may lend an understanding as to the reasons and potential misconceptions about certain engineering ethical dilemmas.

With that said a second area of future research lies in studying the pedagogy itself. It is clear from the results of the regression model that the type of engineering *student* influences the quality of solution and/or the type of engineering ethics *course* that the students take. Participants in this research, who had an engineering ethics class, took either a required class (in case of bioengineering majors), or as an elective offered to all engineering majors (here, civil and industrial engineering majors). Further analysis by the "*type*" of ethics course (i.e., teaching pedagogy, epistemology, content coverage, instructional quality) could provide a better understanding of best practices in engineering ethics training.

Third, in this study we measured "time spent" on each of the behavioral observations' categories/attributes as defined in Table 4 p.38 as a means for evaluating the HPR process. The total time spent on each sub-process was recorded and used in this study. Future research may fill this research gap by investigating other variables associated with the solution process and resolution quality. For example, perhaps time is not as important as the number of transitions and iterations between the various processes. Further, team roles and members' involvement in the process at the different stages of the discussion might influence the quality of the resolution. It is recognized that this type of investigation requires a more cognitive perspective of data analysis utilizing more qualitative techniques.

Fourth, in this study the subjects were selected from one institution generally assumed to have students with the same moral/cultural background and thus a fairly homogeneous group of subjects. A similar study with subjects from more diverse institutions may be conducted to detect if subjects' moral background and/or cultural background is an important variable in engineering decision making involving ethical issues.

Fifth area not addressed in this research was the comparison of different curriculum approaches to evaluate the best approach in teaching ethical decision making. Coupled to the fourth area of future research would be to conduct a cross-institutional study of the various curriculum approaches with potentially a larger diversity of engineering students.

Finally, a sixth research avenue not explored in detail in this research was the use of engineering codes. In our model, use of professional codes is a variable; however, we purposefully chose not to provide students with the professional codes to see if the teams and individuals would refer to them in their discussion. Some casual discussion did occur with regards to professional codes, and in particular with civil engineering teams and individuals. As mentioned, Case 1 was taken from Harris, Pritchard, and Rabins (2000); and the resolution for this case cites various engineering codes delineating the better solutions. A future research activity would be to investigate how the professional and legal environment is formally and informally structured into the learning environment.

APPENDIX A

ETHICAL DECISION MAKING MODELS

A.1 FERRELL AND GERSHAM'S CONTINGENCY MODEL

Ferrell and Gresham's model (1985), shown in Figure 6, focuses on the contingent factors (knowledge, values, intentions, and attitudes) that affect the individual decision maker as well as on the organizational determinants of significant others (differential association, role-set configuration) and opportunity (professional codes, corporate policy, rewards and punishments). The model suggests that management has control over ethical decision making in the organization.

Ferrell and Gresham's Contingency Framework is a "multistage model of ethical decision making behavior. It describes a first order interaction between the nature of the ethical situation and the characteristics associated with the individual, significant others, and the opportunity to engage in unethical behavior… The model suggests that the less distance (fewer boundaries) between the individual and significant others, the more influence the latter will have on the individual's decision" (Ferrell, Gresham, and Fraedrich, 1989). The model assumes that an ethical issue or dilemma arises within the social and/or cultural environment. The model is process oriented. "The decision that emerges from this process leads first to behavior and next to evaluation of behavior, which, in turn, is the starting point for a feedback loop to individual and organizational factors" (Jones, 1991). Four propositions from the contingency framework are presented below.

Proposition 1: The more individuals are aware of moral philosophies for ethical decision making, the more influence these philosophies will have on their ethical decision.

Proposition 2: Significant others located in role sets with less distance between them and the focal individual are more likely to influence the ethical behavior of the focal person.

Proposition 3: In general, differential association (learning from intimate groups or role sets) predicts ethical/unethical behavior.

Proposition 4: The opportunity for the individual to become involved in unethical behavior will influence reported ethical/unethical behavior (Ferrell and Gresham, 1985).

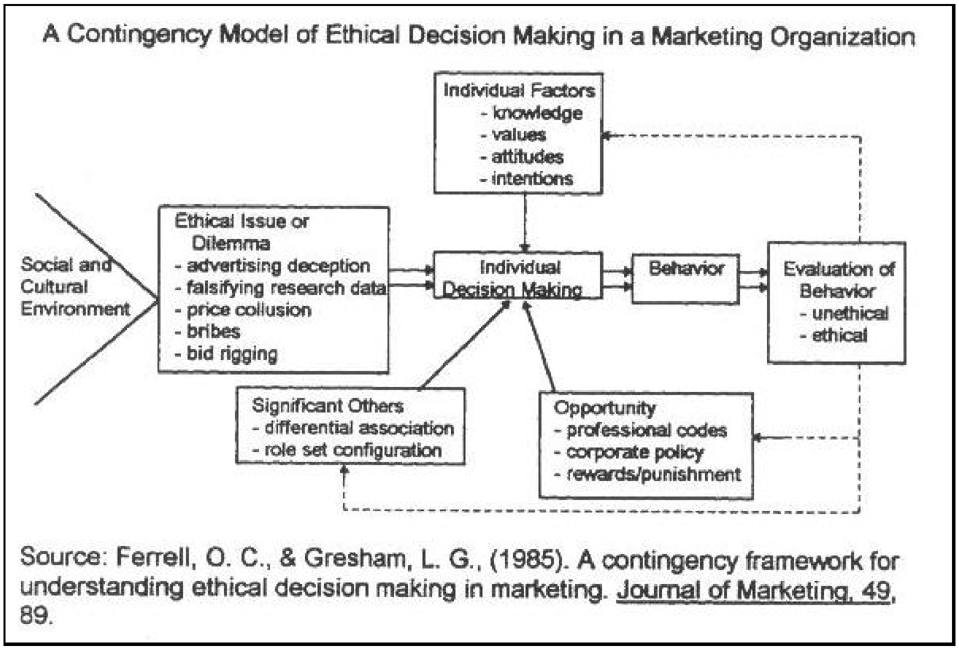


Figure 6 A Contingency Model of Ethical Decision Making

A.2 A JANUS-HEADED MODEL OF ETHICAL THEORY

Until 1985, traditional models of ethical theory presented utilitarianism and formalism (deontology) as antagonistic and mutually exclusive methods. The Janus-headed model proposed by Brady, shown in Figure 7, views the ethical relationship between business and society as a process and allows for a new classification of business/society issues by pointing out their dual nature. It takes its name after the Roman god Janus, the god of gates and entryways, depicted as having two faces – one looking forward and the other backward. A Janus-headed model portrays the social process of resolving ethical issues as simultaneously looking to the past as well as to the future. The model classifies utilitarians as looking forward while formalists are characterized as oriented primarily to the past. Utilitarians approach ethical issues by looking to the future for anticipated results, opportunities, and innovation. The model stresses that business leaders confronted with the ethical dilemma are doing two things at once:

"As formalists they are looking to the cultural heritage established by law, language, and tradition and assessing the relevance and adequacy of the store of knowledge to the issue at hand. As utilitarians they are simply seeking to discover a solution that will give the best possible results according to some idea of what it means to be fully human"(Brady, 1985).

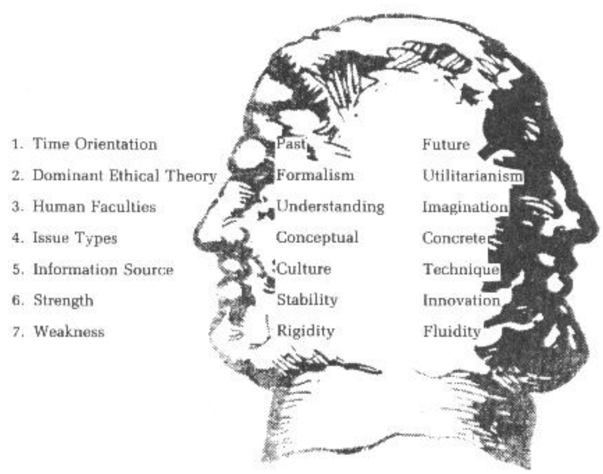


Figure 7 A Janus-Headed Model of Ethical Process

A.3 HUNT AND VITELL'S GENERAL THEORY OF MARKETING ETHICS

Hunt and Vitell developed a general theory of marketing ethics (Hunt and Vital, 1986). The focus in this model, shown in Figure 8, is one way in which an individual perceives the situation, alternatives and consequences. They suggest that once the individual perceives the set of alternatives, a deontological evaluation and teleological evaluation takes place. Deontological norms represent personal rules or rules of behavior which range from beliefs about such things as cheating, product safety, honesty and confidentiality of data. In deontological evaluation the individual evaluates the inherent rightness or wrongness of the intended behavior. Preposition six of this model states that deontological norms are a function of the individual's personal experience, organizational environment, industry environment and cultural environment. The teleological (i.e., consequences) evaluation has four constructs: (1) the perceived consequences of each alternative for various stakeholder groups, (2) the probability that each consequence will occur, (3) the desirability or undesirability of each consequence, and (4) the importance of each stakeholder group. The teleological evaluation results in forming a belief about the relative goodness or "wrongness" brought about by each alternative as perceived by the individual. Hunt and Vitell suggest that combinations of both deontological and teleological perspectives rather than strict adherence to one or the other dominate moral decision-making by individuals. The model also proposes that ethical judgments may often differ from intentions as the teleological evaluation can operate independently in affecting intention construct. Proposition three states that the likelihood that an individual will engage in a particular behavior is a function of situational constraints and the individual's intentions. The model further suggests that when behavior and intentions are inconsistent with ethical judgments, one of the consequences the individual will experience will be guilt.

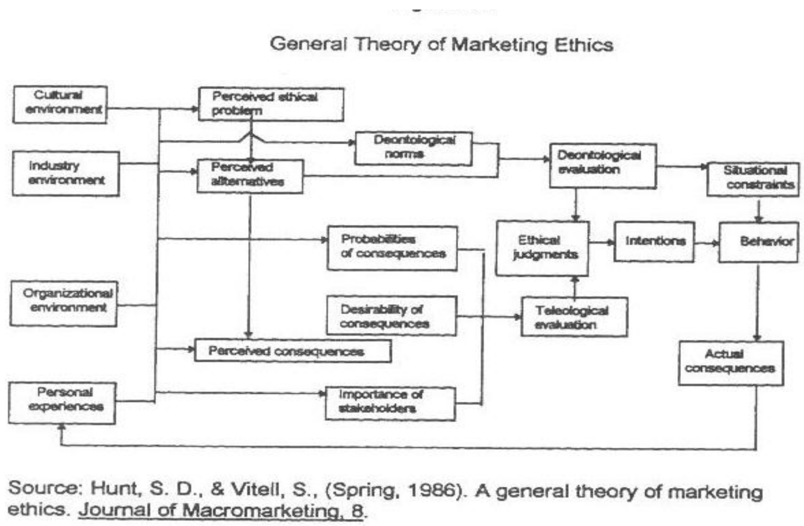
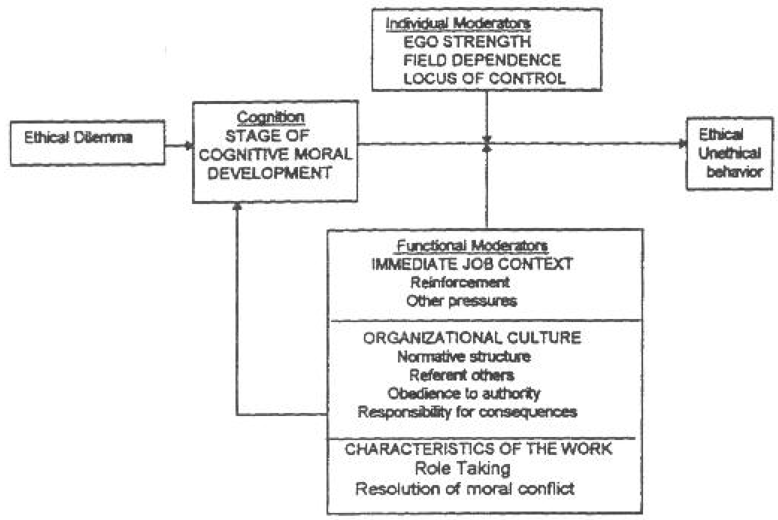


Figure 8 General Theory of Marketing Ethics Model

A.4 TREVINO'S PERSON-SITUATION INTERACTIONIST MODEL

Trevino's 1986 model, shown in Figure 9, is interactionist in nature because it combines individual variables with situational variables to explain and predict ethical decision making behavior of individuals in organizations. This model is based on Kohlberg's cognitive moral development model. Trevino considers Kohlberg's cognitive moral development theory as "the most popular and tested theory of moral reasoning" (Trevino, 1986).

Interactionist model of Ethical Decision Making in Organizations



Source: Trevino, L. K., (1986). Ethical decision making in organizations: A person-situation interactionist model. Academy of Management, 11(3), 601-617.

Figure 9 Interactionist Model of Ethical Decision Making in Organizations

Kohlberg identified three levels of moral development each with two stages (see Table 46). An individual's level of cognitive moral development has an effect upon perceptions of ethical situations. The model assumes that the individual's cognitive moral development stage "determines how an individual thinks about ethical dilemmas… and how additional individual and situational variables interact with the cognitive component to determine how an individual is likely to behave in response to an ethical dilemma" (Trevino, 1985). The individual factors include ego strength, field dependence, and locus of control. The situational factors involve immediate job context (reinforcement and other pressures), organizational culture (normative structure, referent others, obedience to authority, and responsibility for consequences), and characteristics of the work (role taking and resolution of moral conflict). Both individual and situational variables moderate the relationship between the stage of cognitive moral development and ethical/unethical behavior. Trevino's model has no component from moral philosophy.

Table 46 Kohlberg's Stages of Moral Development (Source Elm and Weber, 1994, p. 342)

Level 1: Pre-conventional	Stage 1: Punishment and Obedience Orientation Stage 2: Instrumental Relativist Orientation
Level 2: Conventional	Stage 3: "Good Boy/Nice Girl" Orientation Stage 4: Law and Order Orientation
Level 3: Post-conventional	Stage 5: Social-Contract Legalistic Orientation Stage 6: Universal Principle Orientation

A.5 REST'S ETHICS MODEL

Rest (1986) developed his ethics model, shown in Figure 10, based on the theoretical development of Kohlberg's theory of cognitive moral development and Ajzen & Fisbein's theory of reasoned action (Ajzen and Fishbein, 1975). The premise of the model is that behavior is preceded by behavioral intentions that are, in turn, preceded by individual moral judgments when a moral issue has been recognized.

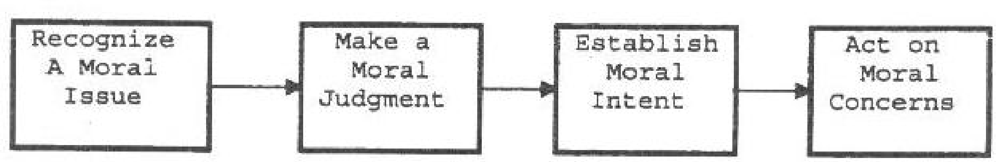


Figure 10 Rest's Ethics Model (Rest, 1986)

A.6 BOMMER, GRATTO, GRAVENDER AND TUTTLE'S BEHAVIORAL MODEL OF ETHICAL/UNETHICAL DECISION MAKING

Bommer *et al.* (1987), proposed their Behavioral Model of Ethical/Unethical Decision Making in 1987, as depicted in Figure 11 The decision making process is influenced by a number of environmental factors such as, work, professional, personal, government/legal, and social. Together with individual attributes (personal goals, personality, motivation mechanism, position/status, self-concept, life experiences, and demographics) environmental factors are regarded as significant influencers of the decision process and resulting behavior. At the same time it is recognized that they have different levels of degree of influence onto the behavior of the individual.

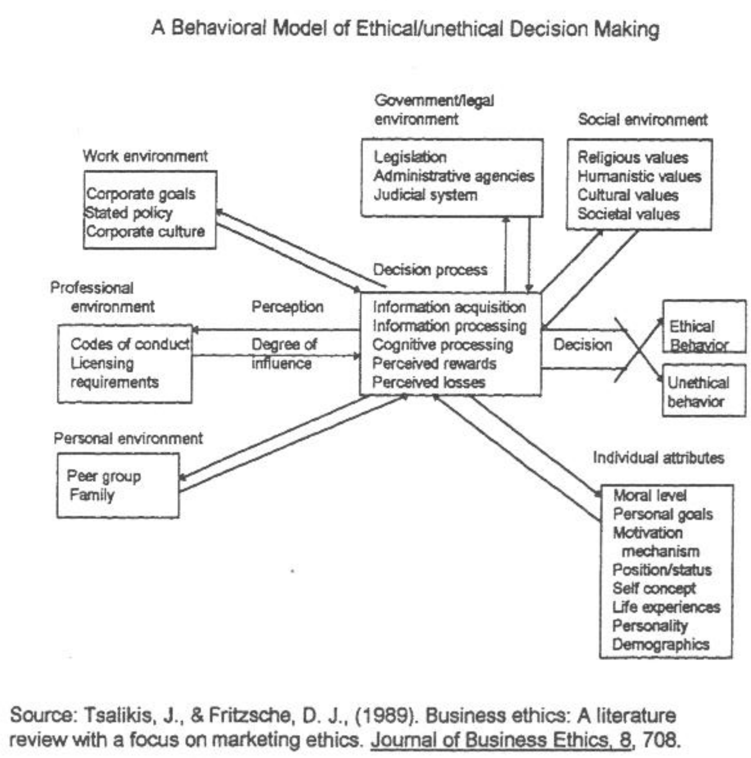


Figure 11 A Behavioral Model of Ethical/Unethical Decision Making

A.7 FERRELL, GRESHAM AND FRAEDRICH'S SYNTHESIS INTEGRATED MODEL (SIM) OF ETHICAL DECISION MAKING

Ferrell, Gresham and Fraedrich (1985), developed the Synthesis Integrated Model (SIM) described in Figure 12, based on the previous findings of Ferrell and Gresham, and Hunt and Vitell. The model contains components of models developed by Ferrell and Gresham, Hunt and Vitell, and Kohlberg. Five stages that occur in the ethical decision making process are identified: identification of ethical issue (awareness), cognitions (stages of cognitive moral development), moral evaluations (deontological and teleological judgments), determination (intentions), and action (ethical/unethical behavior). In the second stage an individual's level of moral development determines how that individual will deal with the dilemma. In the third stage the individual selects the moral philosophy (similar to the Hunt and Vitell model). Intentions from stage four determine actions in stage five. Organizational culture, opportunity and individual moderators affect reasoning process through all four stages. "The use of micro as well as macro constructs blends the cognitive moral development and social learning theories into a more comprehensive view of ethical decision making… How individuals recognize ethical dilemmas is an important issue addresses by the synthesis model" (Ferrell, Gersham, and Fraedrich, 1989).

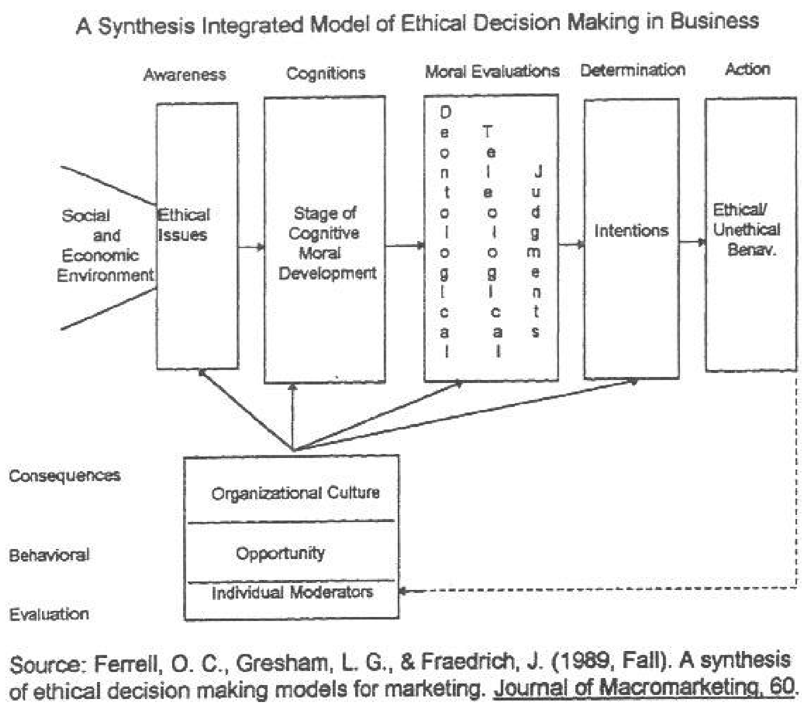


Figure 12 A Synthesis Integrated Model of Ethical Decision Making in Business

A.8 DUBINSKY AND LOKEN'S MODEL FOR ANALYZING ETHICAL DECISION MAKING IN MARKETING

Dubinsky and Loken (1989) developed their model, shown in Figure 13, based on the theory of reasoned action. The model starts with behavioral beliefs, outcome evaluations, normative beliefs, and the motivation to comply. The first two components affect attitudes toward ethical/unethical behavior while the other two affect subjective norms toward ethical/unethical behavior. Intentions to engage in ethical/unethical behavior are result of the individual's evaluation of behavior and beliefs about significant others' approval.

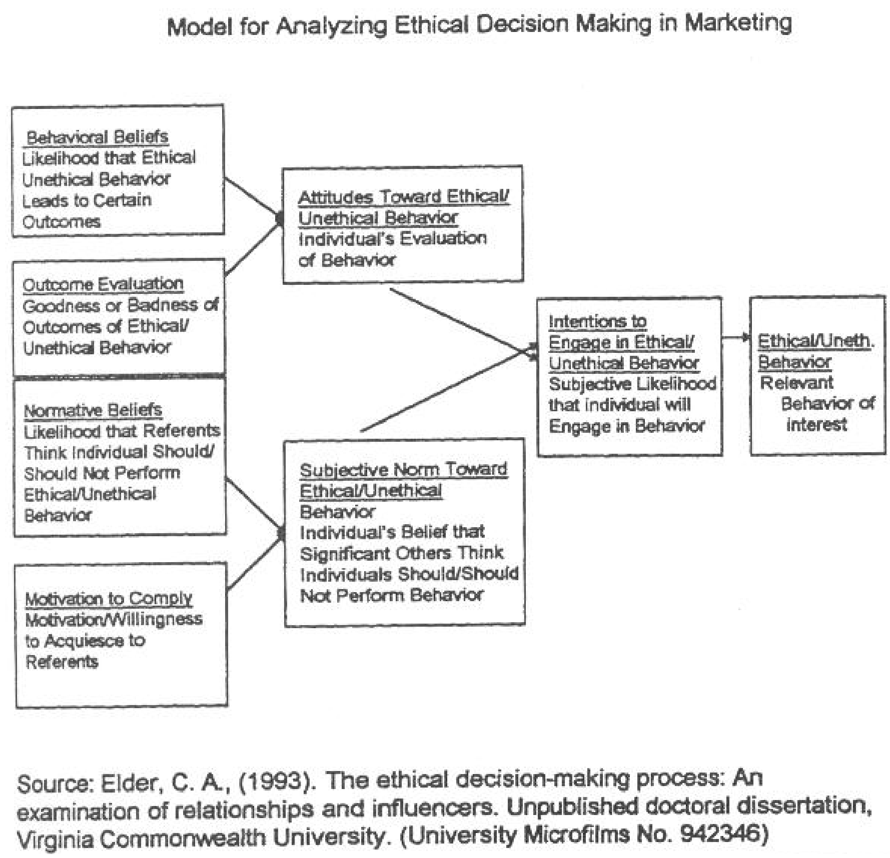


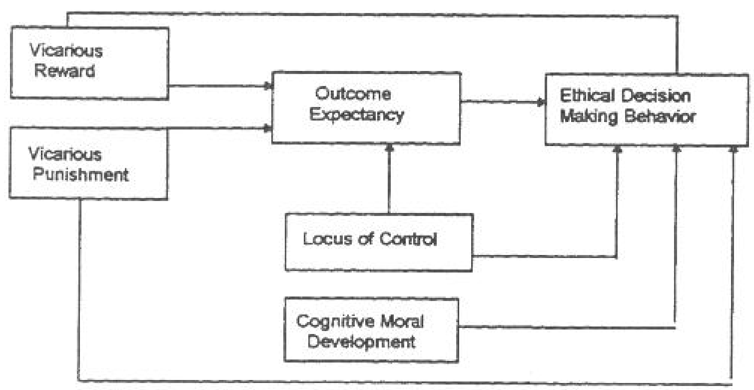
Figure 13 Model for Analyzing Ethical Decision Making in Marketing

A.9 TREVINO AND YOUNGBLOOD'S INTERACTIONIST MODEL OF ETHICAL DECISION MAKING IN ORGANIZATINS

Trevino and Youngblood's 1990 model, shown in Figure 14, took an approach based on social learning theory in which individuals are assumed to learn vicariously by observing what happens to others (Trevino and Youngblood, 1990).

The factors in the model that are related to individual tendencies in ethical decision making include: vicarious reward, vicarious punishment, outcome expectancy, locus of control, cognitive moral development, and ethical decision-making behavior. Their findings determined that one's "locus of control exhibited the single strongest direct effect on ethical decision-making; nearly double that of all the other factors" (Trevino, 1990).

Proposed Model of Ethical Decision Making Behavior in Organizations



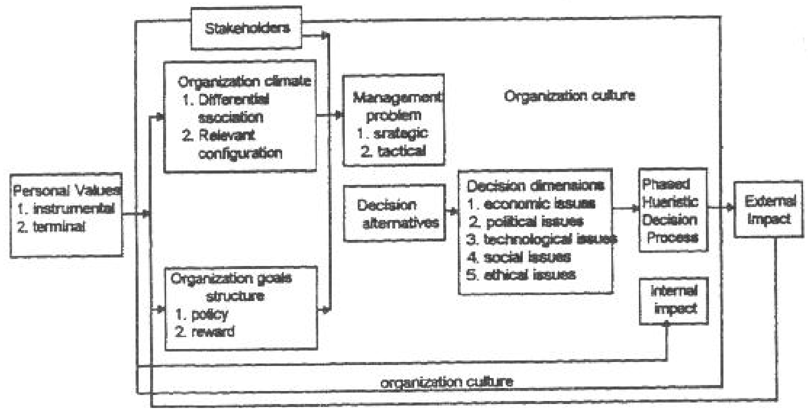
Source: Trevino, L. K., & Youngblood, S. A. (1990). Bad apples in bad barrels: A causal analysis of ethical decision making behavior. Journal of Applied Psychology, 75(4), 380.

Figure 14. Model of ethical Decision-Making Behavior in Organizations

A.10 FRITZSCHE'S MODEL FOR DECISION-MAKING INCORPORATING ETHICAL VALUES

Fritzsche's (1991) model, described in Figure 15, is focused on the set of personal values held by the decision-maker. In business forces within the organizational structure meditate those values. The model offers a way to understand how organizational forces interact with the values of individual decision-makers and how they influence their decisions.

A Model of Decision-making Incorporating Ethical Values



Source: Fritzsche, D. J. (1991, November). A model of decision-making incorporating ethical values. Journal of Business Ethics, 10(11), 843.

Figure 15 A Model for Ethical Decision Making Incorporating Ethical Values

APPENDIX B

NORMATIVE MODELS

B.1 CAVANAGH, MOBERG, AND VELASQUEZ'S THE ETHICS OF ORGANIZATIONAL POLITICS MODEL

Cavanagh, Moberg and Velasquez (1985) model shown in Figure 16, used the three theories of utilitarianism, rights and justice in a decision tree for incorporating ethics into a decision model. They have studied the concept of power in organizations and developed a model for making decisions that reflects the optimum political behavior alternative (PBA). While their model may be helpful in analyzing the ethical dimensions of a conflict-oriented situation, it does not eliminate the need to confront ethical dilemmas to the extent of one's cognitive capabilities and is not a substitute for individual discretion.

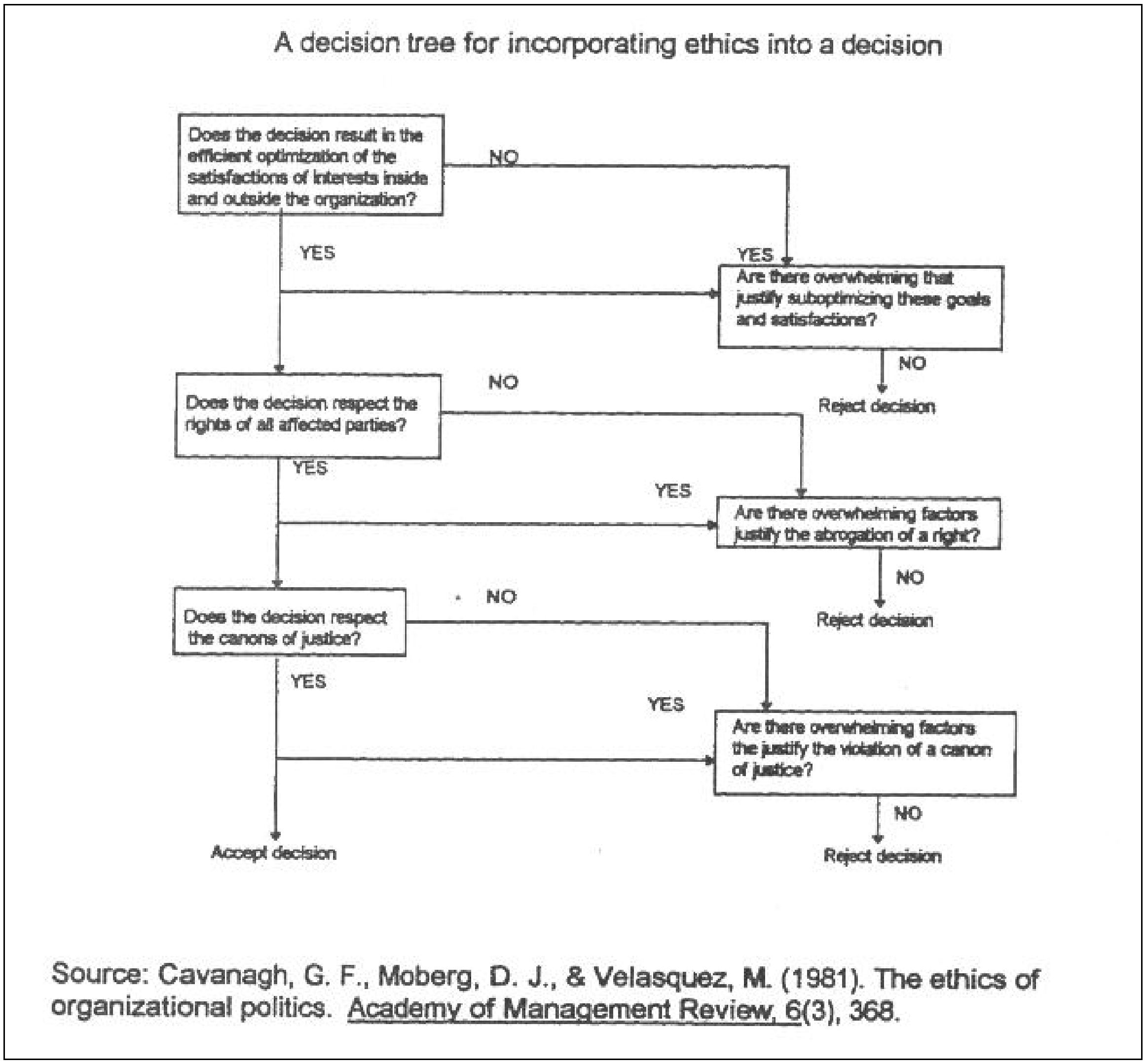


Figure 16 A Decision Tree for Incorporating Ethics into a Decision

B.2 PROCEDURES PROVIDED BY MANNER

Manner (1999) collected and studied over fifty procedures described in the literature representing a variety of decision-tree like approaches to ethical decision–making. Most of the procedures were designed to meet specific needs for persons in certain types of situations. Based on the study he proposed a twelve-step procedure shown in Table 47.

Table 47 Manner's 12 Step Procedure (Adapted from Manner, 1999)

STEP	DESCRIPTION
1	**The Preparing Stage** During this earliest stage, we cultivate moral awareness and sensitivity, clarify our value system and worldview, observe human nature, engage in ethical behavior, learn some ethical theory, and prepare to avoid ethical traps.
2	**The Inspecting Stage** We now face a possible problem situation, so we attempt to define the problem by listing facts, participants, groups, roles, relationships, events and actions. At this stage, we make no effort to determine what is *morally* relevant, only what is *factually* relevant, and we try to produce a list of un-controverted facts that would be acceptable to all parties. Finally, we determine whether the situation is truly a problem, one that requires further attention and action.
3	**The Elucidating Stage** Here we identify facts that are missing, and either develop these new facts or make assumptions to cover them. We clarify technical, ambiguous or vague concepts, and we try to eliminate biased and emotionally charged language. We isolate key factors in the situation, including especially factors that set this situation apart from otherwise similar cases. We identify the difficulties and obstacles that may hinder analysis. We do epistemological legwork, trying to assess the reliability of our sources and the validity of our information. We try to determine the immediate antecedents of the problem, how the situation came to be. We discriminate between primary and secondary participants, and we determine which parties are affected by actions of other parties. Potentially, these affected parties are the stakeholders, but we do not make that association until the Focusing Stage. We consider all the lists we have made, and eliminate from these lists any items that do not meet some minimum threshold for significance. Given all this, we try to estimate whether this is a short-term problem that can be resolved quickly, or a long-term problem that requires sustained effort. Finally, in a very preliminary way, we begin to frame possible issues: "Is it true that X should do Y assuming Z?"
4	**The Ascribing Stage** We begin to infer and specify the values, goals, ideals, interests, ideologies, priorities and motives that are most likely responsible for creating the dynamics of the problem. We ascribe these biases, tendencies and proclivities to various participants or to ourselves.

Table 47 (continued)

5	**The Optioning Stage** We brainstorm to list all possible courses of action that are (or were) available to the participants. This list may include actions that are ill-advised and actions that are contingent on other actions. Once we know the full range of alternatives, we try to eliminate from the list those actions that are clearly not feasible or that fail to meet some threshold for relevance. We do not exclude an option because we think it is wrong.
6	**The Predicting Stage** For each remaining option, we list potential consequences, including consequences that would result if no action were taken. We discriminate between short- and long-term effects, between likely and unlikely consequences, and between results that are intended and unintended. We associate these consequences with specific participants or with ourselves, either as a risk or as a benefit.
7	**The Focusing Stage** We consider all affected parties and identify those who are sufficiently affected to be elevated to stakeholder status. We note the rights that are claimed, or could be claimed, and we identify the responsibilities or duties that correspond to those rights. We determine which facts are morally relevant, which actions have moral consequences, which values are moral values, which questions are moral questions, and which issues are moral issues. We take special note of virtues, values, rights, priorities and ideals that appear to be at risk, or that appear to be in conflict. We eliminate all factors that are morally irrelevant or insufficiently relevant. Based on all this analysis, we identify and define the core ethical issue, which is often expressed as a dilemma: "Should X do or not do Y assuming Z?"
8	**The Calculating Stage** Some decision-making procedures attempt to quantify risks, costs, benefits, burdens, impact, likelihoods and even relevance. These weights and numbers, if required, are generated at this stage. Later, at least in theory, it will be easy to determine which option produces the greatest probable morally relevant benefit with the least probable morally relevant risk.
9	**The Applying Stage** This is the stage where most of the critical work of applied ethics is done. Ideally, each possible stakeholder/action pair is considered separately and sympathetically. Reasons for and against particular actions are cataloged, then ranked. Morally required actions are distinguished from those that are morally permitted but not required. Values are weighed against other values. Sometimes entire value systems are weighed against competing systems. Short-term benefits are weighed against long-term risks. In similar fashion, long-term benefits are weighed against short-term risks. Various ethical theories may come into full play -- and into full conflict. Like and unlike cases are considered and compared. We construct moral analogies and dis-analogies, examples and counter-examples. Best- and worst-case scenarios are elaborated. Diverse ethical principles are applied, and we note whether their advice is conflicting or convergent. Options are evaluated according to the virtues they promote, or the rights they respect, or the obligations they satisfy, or the values they maximize, or the principles they obey. Philosophical arguments are constructed, deconstructed and evaluated. Laws, policies, ethical codes, and professional literature are reviewed for parallels. Associates, supervisors, mentors, trusted friends, advisors and stakeholders (if willing and available) give the decision-maker the benefit of their opinions. Results may be convergent but typically are conflicting, contradictory or inconsistent.

Table 47 (continued)

9	Since conflicts are so common, special strategies are invoked to resolve them. When the dust settles, we hope the problem has been reduced to a coherent set of pivotal considerations. If this happens, the long list of options produced in Stage 5 can be shrunk to a much shorter list of promising options. For these remaining options, full justifications are prepared.
10	**The Selecting Stage** An option is chosen, and that decision is confirmed by applying a series of informal, commonsense ethical tests (e.g., the Reversed Roles Test or the Public Scrutiny Test). As a double-check, we may perform a "sensitivity analysis" to identify those situational factors that, if altered, would alter our decision. We would then revisit our analysis of those factors. All things considered, we may not be 100% comfortable with our decision. Even so, we should reach a settled state of "wide reflective equilibrium." If not, we may decide to re-start the analysis at an earlier stage, time permitting
11	**The Acting Stage** We plan exactly what is to be done step by step, and who is to do it. We try to ensure due process for all stakeholders. We establish a timetable. We identify the means to be employed. We gather the necessary resources. We develop indicators of success and failure, including some early indicators. Finally we take action, and we take responsibility for the consequences.
12	**The Reflecting Stage** In this final stage, we monitor the decision as it is implemented with special attention to the effects it is having on stakeholders. We assess the results as they unfold using the indicators developed in the previous stage. If, by those indicators, the decision is failing, we may re-implement the decision, and if that also fails, we may abort and start over, circumstances permitting. Otherwise we live with the decision and learn from it. When finished monitoring, we may recommend new policies to address particular issues. We may review and evaluate the decision procedure itself with an eye toward process improvement. Did the procedure work as intended? Were the steps in the correct order? Finally, we may consider what could have been done in the first place to prevent the problem and, where appropriate, take steps to prevent recurrence.

B.3 A TREE-LIKE DECISION PROCESS (HARRIS, ET AL., 1997)

Table 48 Analyzing and Resolving Ethical Problems (Adapted from Harris et. al., 1997)

Step	Description
1.	1. Decomposing Moral Problems: The Three Components a. Factual Question i. Questions a fact that is relevant to the moral problem that is controversial ii. If problem is a factual disagreement it will be very hard to resolve b. Conceptual Question i. Questions the meaning of a term or concept ii. Because people interpret terms and concepts in various ways, this type of problem needs to be solved by looking at the facts in addition to the term or concept that is most generally accepted by the majority c. Ethical Question i. Questions how the action or person should be evaluated. ii. These question fall into two categories: 1. Conflict problems: an issue cannot be resolved because all moral obligations cannot be met simultaneously 2. Line-drawing problems: an issue falls somewhere in between actions that are definitively right and those that are definitively wrong.
2	2. Conflict Problems a. Types of Choices i. Easy Choices 1. One obligation is clearly more applicable/important to follow in a certain situation 2. This decision is not easy to carry out, but it is easy to know what should be done in the situation ii. Creative Middle Ways 1. A solution that honors several obligations, but perhaps not in their purest form 2. Necessary to compromise among several competing. obligations. iii. Hard Choices 1. Situation in which several competing obligations are important and cannot be compromised 2. This choices are extremely hard to make, and learning how to avoid them is a major concept when learning engineering ethics 3. If these choices are necessary, it is important to employ tact, good communication, and common sense b. Devising a Solution i. Arrange options into a series 1. Most creative-middle-way solution 2. Less desirable solutions 3. Hard choices ii. Weigh all of the options 1. Decide which options meet the most criteria 2. Continue to narrow down list until best option surfaces.

Tale 48 (continued)

3	3. Line-Drawing Problems a. Cases i. Questionable case 1. Case in question ii. Paradigm case 1. Case in which there is no question 2. Used as a comparison to a questionable case 3. Two types: a. Positive: action is clearly morally right b. Negative: action is clearly morally wrong iii. Intermediate case 1. Cases that can be placed between two paradigm cases b. Devising a Solution i. Look at similarities and differences between questionable case and the paradigm and intermediate cases ii. Important to keep the moral significance, and not only the similarities and differences, in mind iii. Decide where the questionable case fits among the paradigm and intermediate cases.

APPENDIX C

INSTRUMENTS THAT MEASURE MORAL REASONING

C.1 MORAL JUDGMENT INTERVIEW(MJI)

The Moral Judgment Interview (MJI) was developed in the 1980s with the purpose of operationalizing Kohlberg's theory on the stages of moral development. Kohlberg induced that (1) "morality" is an individually defined, progressive phenomena, and (2) moral judgments result from an individual's cognitive ability to interpret social events (Rest and Navarez, 1994). The initial MJI procedure involved interviewing a subject after being presented with a series of situations involving moral conflicts. The subject is asked to answer a series of open-ended questions that are explicitly prescriptive so as to draw out normative judgments about what one should do, rather than descriptive or predictive judgments about what one would do. These responses enable the researcher to identify a single or a combination of stages of moral reasoning used by the individual. The MJI is designed to "elicit a subject's (1) own construction of moral reasoning, (2) moral frame of reference or assumptions about right and wrong, and (3) the way these beliefs and assumptions are used to make and justify moral decisions" (Colby and Kohlberg, 1987).

The scoring method has been revised over the years in order to makes it less cumbersome. Colby and Kohlberg (1987) describe and outline a 17-step process for coding the subject's response into a stage score. The steps are divided into three sections: (1) breaking down the interview material into interview judgments (steps 1 through 6), (2) matching the new interview judgments with previous (standardized) interview judgments found in the scoring manual (steps 7 through 14), and assessing stage scores (steps 15 through 17).

C.2 MULTIDIMENSIONAL ETHICS SCALE (MES)

Flory *et al.* and Cohen *et al.* developed the MES (Flory, Philips, Reidenbach, and Robin, 1992; Cohen, Plant, and Sharp, 1996; Cohen, Plant, and sharp, 2001). They used the MES to measure ethical awareness, ethical orientation, and intention to take questionable actions. The MES as the measurement instrument permits insights into the cognitive ethical reasoning process and complements the DIT. The MES offers the advantages that (1) specific modes (justice, deontology, utilitarianism, and egoism) of moral reasoning can be identified, and (2) it can be employed in profession-specific situations. These features permit the findings to be used to identify profession-relevant, specific errors in moral reasoning, which can be remedied in training programs (Cohen, Plant, and sharp, 2001).

The instrument consists of a number of vignettes describing a wide variety of ethical dilemmas that might be meaningful and faced by a professional. The MES comprises a multi-item scale, shown in Figure 17, in which respondents indicate the extent to which they believe that a particular action, described in a particular vignette, is ethical or otherwise according to a given criterion. Five ethical theories are included in the instrument:

1. justice (the idea of fairness to all),
2. deontology (the extent to which an action is consistent with an individual's duties or unwritten obligations),
3. relativism (the extent to which an action is considered acceptable in a culture),
4. utilitarianism (the extent to which an action leads to the greatest good for the greatest number of people), and
5. egoism (the extent to which one chooses an action based on self-interest).

Means for all items can be computed and an analysis of covariance (ANCOVA) is then performed for the ethical criterions (ethical theories). Reidenbach and Robin (1990) have later since modified MES to include only eight items.

Just	I_I_I_I_I_I_I_I	Unjust
Unfair	I_I_I_I_I_I_I_I	Fair
Morally right	I_I_I_I_I_I_I_I	Not morally right
Not acceptable to my family	I_I_I_I_I_I_I_I	Acceptable to my family
Culturally acceptable	I_I_I_I_I_I_I_I	Culturally unacceptable
Traditionally unacceptable	I_I_I_I_I_I_I_I	Traditionally acceptable
Not self-promoting for the actor	I_I_I_I_I_I_I_I	Self-promoting for the actor
Personally satisfying for the actor	I_I_I_I_I_I_I_I	Not personally satisfying for the Actor
Produces the greatest utility	I_I_I_I_I_I_I_I	Produces the least utility
Minimizes benefit while maximizes harm	I_I_I_I_I_I_I_I	Maximizes benefits while minimizes harm
Does not violate an unwritten contract	I_I_I_I_I_I_I_I	Violates an unwritten contract
Violates an unspoken promise	I_I_I_I_I_I_I_I	Does not violate an unspoken promise
The probability that I would undertake the same action is		
High	I_I_I_I_I_I_I_I	Low
The probability that my peers would undertake the same action is		
High	I_I_I_I_I_I_I_I	Low
The action describe above is		
Ethical	I_I_I_I_I_I_I_I	Unethical

Figure 17 Multidimensional Ethics Scale (Adapted from Cohen *et al.*, 1996)

C.3 ETHICS POSITION QUESTIONNAIRE (EPQ)

Schlenker and Forsyth developed the EPQ (Schlenker and Forsyth, 1977; Forsyth, 1980). The EPQ was designed to measure ethical ideology along two dimensions, relativism and idealism. The EPQ consists of twenty statements in a Likert scale format. Ten of the statements are designed to assess idealism while the other ten assess relativism. Typical items designed to assess idealism include "risks to another should never be tolerated, irrespective of how small they might be" and "if an action could harm an innocent other, then it should not be done". Typical items designed to assess relativism include "there are no ethical principles that are so important that they should be part of any code of ethics" and "questions of what is ethical for everyone can never be resolved since what is moral or immoral is up to the individual" (Barnett, Brass and Brown, 1994).

The EPQ has consistently demonstrated acceptable levels of reliability (Forsyth, 1980; Barnett, Bass, and Brown, 1994). Davis, Anderson and Curtis examined the construct validity of the EPQ by including a third factor – veracity. They concluded that the relationship between EPQ measures of idealism and moral judgments demonstrated modest predictive validity, but the appreciably weaker influence of relativism and the emergence of a veracity factor raised questions about the utility of the EPQ typology (Davis, Andersen, and Curtis, 2001).

C.4 ROKEACH VALUE SURVEY (RVS)

American social psychologist Milton Rokeach (1993) developed a survey instrument called Rokeach Value Survey (RVS) in 1973. He defines value as:

"A value is an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (Rokeach, 1973, p.5).

In the above definition, a "mode of conduct" refers to those values that he calls "instrumental values". The other dimension in Rokeach's definition is "end-state of existence" which corresponds to his "terminal values" classification.

Rokeach identifies 36 values, 18 terminal values and 18 instrumental values. Terminal value items are designed to measure the relative importance of end-states of existence (personal goals). Instrumental value items measure basic approaches an individual might take to reach end-state values. Instrumental values are basically the kind of personal characteristics that we think highly of. Terminal values are the goals in life that we think are most important and that we feel are most desirable. The two lists were designed to be reasonably comprehensive. Values are presented in alphabetical order and the respondent is asked to rank those values in order of importance by writing in numbers from 1 to 18 (1=most important, 18=least important).

Table 49 lists the 36 values and their definitions.

Table 49 Terminal and Instrumental Values

Terminal Value	**Instrumental Value**
1. A comfortable life (a prosperous life)	1. Ambitious (hard-working, aspiring)
2. An exciting life (a stimulating active life)	2. Broadminded (open-minded)
3. A sense of accomplishment (lasting contribution)	3. Capable (competent, effective)
4. A world of peace (free of war and conflict)	4. Cheerful (lighthearted, joyful)
5. A world of beauty (beauty of nature and the arts)	5. Clean (neat, tidy)
6. Equality (brotherhood, equal opportunity for all)	6.Courageous (standing for your beliefs)
7. Family security (taking care of loved ones)	7. Forgiving (willing to pardon others)
8. Freedom (independence, free choice)	8. Helpful (working for the welfare of others)
9. Happiness (contentedness)	9. Honest (sincere, truthful)
10. Inner harmony (freedom from inner conflict)	10. Imaginative (daring, creative)
11. Mature love (sexual and spiritual intimacy)	11. Independent (self-reliant, self-sufficient)
12. National security (protection from attack)	12. Intellectual (intelligent, reflective)
13. Pleasure (an enjoyable, leisurely life)	13. Logical (consistent, rational)
14. Salvation (saved, eternal life)	14. Loving (affectionate, tender)
15. Self-respect (self-esteem)	15. Obedient (dutiful, respectful)
16. Social recognition (respect, admiration)	16. Polite (courteous, well-mannered)
17. True friendship (close companionship)	17. Responsible (dependable, reliable)
18. Wisdom (a mature understanding of life)	18. Self-controlled (restrained, self-disciplined)

Weber (1993) explored the relationship between personal values and moral reasoning to better understand, explain, and possibly predict decision-making and reasoning process.

C.5 ETHICAL RESONING INVENTORY (ERI)

The Ethical Reasoning Inventory (ERI), an objective instrument for assessing moral reasoning, was derived from Kohlberg's Standardized Scoring Manual (Forms A and B) by utilizing standard probe questions to each dilemma by Page and Bode (1980).

A total of 26 questions were derived from the six dilemmas in the manual. Where possible, answers to each question were written representing responses characteristic at stages 1 through 5 in Kohlberg's model. Stage 6 was excluded since it rarely occurs. In addition to the responses representing different stages, there were also items designated "nonsense" and "abstract".

The ERI employs a form of branching technique to present the dilemmas and various response options. Each set of choices is followed by the next question, and so on. It takes about 50 minutes to complete the ERI (46 pages). Scores on the ERI are obtained by calculating the average stage selection with stage 1 assigned a value of 1, stage 2 a value of 2, etc. An alternative to using the averages is to "stage type" individuals according to the modal stage selected.

C.6 MEASURE OF MORAL VALUES

Hogan and Dickstein (1972) developed a Measure of Moral Values in 1972. Measure of Moral Values instrument consists of a series of 15 statements each posing a concrete moral issue. Statements were carefully constructed to contain an identifiable element of injustice, were expressed in simple matter-of-fact language, and contained the maximum ambiguity consistent with clarity. Respondents are instructed to read each statement carefully and assume that it has been made by a person with whom they are having a conversation. Then, on the line below each statement they are to indicate their reaction. Responses are graded for “maturity of moral judgment” using the following scoring elements: concern for the sanctity of the individual, judgments based on the spirit rather than the law, concern for the welfare of society as a whole, and capacity to see both sides of an issue. A response was assigned 2 points if any of the four scoring elements was clearly present, 1 point if any of the four elements could be easily and readily inferred and 0 points if none of the score elements was present. The scores could range from 0 to 30. The 15 statements are listed below.

1. The FBI has its hands tied in many cases because of the unreasonable opposition of some people to wiretapping.
2. [Black speaker] Even after graduating from high school, I can’t find work. Yet, I know many white dropouts who have good jobs.
3. The city is going to repeat what has been done in many other cities by building a superhighway right through the slum district. Many apartments will be torn down and the people will be forced out.
4. Some boys have it so easy. They go to college and get out of the draft, and we get sent to Vietnam.
5. I told Jack my ideas for the new project. He took them to the boss and got the credit.
6. The new housing law is unfair. Why should I be forced to take in tenants that I find undesirable?
7. In many medical laboratories, experiments are performed on live animals and very little care is taken to minimize pain.

8. I read another story today about a girl who was refused an abortion in a hospital. An incompetent doctor gave her an illegal abortion and she died.
9. I think it is unnecessarily cruel to keep condemned prisoners on death row for so long, and to make execution such an elaborate ritual.
10. The police should be encouraged in their efforts to apprehend and prosecute homosexuals. Homosexuality threatens the foundations of the society.
11. A powerful group representing hunters and gun manufacturers is holding up a gun control law that the majority of the people in this country want.
12. The government shouldn't have passed the Medicare bill. Why should we pay other people's doctor bill?
13. Several policemen were called into a slum area to break up a street fight but when they arrived the local residents threw bricks at them from the windows.
14. During last year's ghetto riots a shop owner saw a boy jump out of the broken window of his store with a television set. The man shot the boy, who is now crippled as a result.
15. The police were rough when they broke that crowd of students even though the students were parading without a permit.

C.7 UNIVERSAL VALUES SURVEY

Following the work of Rokeach, Schwartz (1994) began the effort to resolve the issue of classifying value content. He derived ten value types defined in terms of its central goal, as follows.

1. Power: Social status and prestige, control or dominance over people and resources.
2. Achievement: Personal success through demonstrating competence according to social standards.
3. Hedonism: Pleasure and sensuous gratification for oneself.
4. Stimulation: Excitement, novelty, and challenge in life.
5. Self-direction: Independent thought and action-choosing, creating, exploring.
6. Universalism: Understanding, appreciation, tolerance, and protection for the welfare of all people and for nature.
7. Benevolence: Preservation and enhancement of the welfare of the people with whom one is in frequent contact.
8. Tradition: Respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide.
9. Conformity: Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations and norms.
10. Security: Safety, harmony, and stability of society, of relationships, and of self.

Fifty six values are included in the core survey, 52 to represent the ten postulated value types and 4 to capture a possible spirituality type. The values are presented in two lists, the first 30 phrased as terminal values (nouns), and the remaining 26 as instrumental values (adjectives), each followed by an explanatory phrase. Respondents rate each value on 9-point importance scale “as a guiding principle in my life,” from 7 (of supreme importance), to 0 (not important), to –1 (opposed to my values). Respondents choose and rate their most and important values prior to rating the values on each list thereby anchoring their use of response scale.

APPENDIX D

RUBRIC

The Pittsburgh-Mines (P-M) Engineering Ethics Assessment Rubric*

September 5, 2003

Larry Shuman**, Mary Besterfield-Sacre, Mark Sindelar, Harvey Wolfe (U. of Pittsburgh) and Ronald Miller, Barbara Olds, Carl Mitcham (Colorado School of Mines)

Attribute	Level 1	Level 2	Level 3	Level 4	Level 5
Recognition of Dilemma (Relevance)*	• Doesn't see problem. • At best only infers a problem	• Identifies problem(s); may infer that it is an ethical dilemma(s).	• Recognizes obvious ethical dilemma(s).	• Able to recognize less obvious ethical dilemma(s).	• Clearly identifies and frames key ethical dilemmas, or summarizes in broader context
Information (Argumentation)	• Uses misinformation. • Uses facts incorrectly. • Ignores pertinent facts.	• Lists facts without judgment or discussion. • May be missing key facts. • Only identifies certain actors. • May recognize, but misinterpret certain facts.	• Justifies facts relevant to identified dilemmas. • Notes some information is missing. • Identifies most key actors.	• Recognizes some "unknown facts." • Makes assumptions to address missing information. • Identifies all relevant actors.	• Recognizes and justifies unknown facts in addition to known facts. • Identifies primary and secondary actors. • May use own expertise to add appropriate information.
Analysis (Complexity and Depth)	• No analysis provided. • Defaults to a superior or authority without further elaboration. Takes a definitive and unambiguous position without justification. • Any analysis appears to have been done without reference (explicit or implicit) to guidelines, rules or authority.	• Authoritative rule driven without justification. Position may be less definitive (e.g., "should do" vs. "must do"). • Minimal effort at analysis and justification. • Relevant rules ignored. • May miss or misinterpret key point or position. • If ethical theory is cited, it is used incorrectly.	• Applies rules or standards with justification, notes possible consequences or conflicts. • Correctly recognizes applicability of ethical concept(s). • Recognizes that contexts of concepts must be specified. • Coherent approach	• Applies rule or standard considering potential consequences or conflicts. • Uses an established ethical construct appropriately. • Considers aspects of competence and responsibility of key actors. • May cite analogous cases. Partial (incomplete) specification of contexts of concepts.	• Correctly applies ethical constructs. • May offer more than one alternative resolution. • Cites analogous cases with appropriate rationale. • Thorough evaluation of competence and responsibility of key actors. • Considers elements of risk for each alternative. • Explores context of concepts.
Perspective (Fairness)	• No perspective; focus wanders.	• Gives one point of view.	• Some acknowledgment of multiple perspectives, but favors only one perspective.	• Considers relevant, multiple perspectives.	• Has a global view of situation • Considers consequences of various perspectives..
Resolution (Argumentation)	• None; not responsive to original dilemma. • Proposed resolution lacks integrity; dishonest.	• Only applies or cites rules with little or no justification; may be using rules out of context. • Only states possible resolution(s) • Only infers consequences	• Limited ability to use facts to differentiate among alternatives. • Proposed resolution is feasible • Recognizes recommendation has consequences.	• Proposes several alternatives and considers consequences of each. • Considers potential of risk to public and/or safety. • Incomplete win-win solution suggested.	• Resolves case through clear argumentation and consideration of all primary stakeholders. • Understands consequences of various actions. • Proposes creative middle ground (win-win situation) solution.

* Supported by the National Science Foundation, DUE01 27394 "Assessing Engineering Students' Understanding of Their Professional and Ethical Responsibilities."

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APPENDIX E

FACTORS IN ETHICAL DECISION MAKING PROCESS

Table 50 Individual Factors

Individual Factors	Instrument
1**. *LEVEL OF MORAL DEVELOPMENT***	
Cognitive moral development level. Level of moral development (Kohlberg stage of moral development)	DIT, MJI
Moral level. (Bommer '87) As defined by Kohlberg	DIT
Ethical Judgment. Valentine dis.	MES- Multidimensional Ethics scale.
2. ***INDIVIDUAL'S VIEW OF HIM/HERSELF***	
Locus of control. Rotter's (1966) developed Rotter's internal/external scale measures an individual's perception of how much control he or she exerts over the event in life. An internal is more likely to take responsibility to take responsibility for consequences and relay on his or her behavior. Trevino	Rotter's scale. McDonald and Tsen'71 11 item Interna/external Locus of Control Scale based on James '57 in Cherry dis.
Ethical Self-efficacy. Employees' perceptions regarding job skills, abilities, job qualifications, and confidence in their job. (Ferrell L, Fl dis.) Also in Flannery dis.	Jones (1986) 8-item scale 1-5 reduced to 4-items in Fl dis. Specific to cases 7 point Likert scale Bandura '77 in Flannery dis.
Self-concept. (Bommer '87)	
Attitudes about ethical dilemma. Teague dis. Individuals feelings about being able to confront ethical dilemmas. Teague dis. Similar to self -efficacy, self-concept., Ferrell and Gresham.	10 Likert scale items. By Teague
Personality characteristics such: as locus of control, neuroticism, authoritarianism, level of anxiety. (Bommer '87)	
Personal goals. (Bommer '87)	
Ego strength. Related to strength of conviction or self-regulating skills. Individuals high on a measure of ego strength are expected to resist impulses and follow their convictions more than individuals with low ego strength. It is a measure of consistency between moral judgment and moral action. Trevino	
Motivation mechanism: safety vs. esteem. Esteem motivated individuals do not submit to group pressure while safety motivated subjects tend to acquiesce to group pressure and exhibit inconsistent moral action (Ward and Wilson) in (Bommer '87)	
3. **INDIVIDUAL VS. ORGANIZATION**	
Ethical Independence. Individual's perceived decision autonomy in the ethics area in their specific organization and their adherence level to company policies and procedures. (Ferrell Linda, Fl)	Victor and Cullen (1987) ethical climate scale. 8-items scale.

Table 50 (continued)

Field dependence. Degree to which people are depending on the information/opinion provided by external social referent. Field independent people function with greater autonomy. Trevino	
Ethical Concern. Individual's view on the importance of ethics and ethics training. (Ferrell L, Fl)	Zaichkowsky's (1985) scale. 8-items.
Motivation to comply represents the motivation, or willingness, of an individual to adhere to what he or she believes important referents want him or her to do. Fishbein and Ajzen, 1975 in Dubinsky/Loken	Respondents were asked for each referent: "When it comes to my job, I want to do what [referent] thinks I should do."7 point Likert scale.
Socialization Practices. Socialization tactics in an organization. (Ferrell L, Fl dis)	VanMaanen and Schein (1979) 5-item scale.
Position/status. (Bommer '87)	
Instrumental climate. Individual's perception of ethical dimension of their organization. (Flannery).	Victor and Cullen '88 organizational climate.
Subjective norm refers to one's perception of whether others important to the individual think he or she should or should not engage in a given behavior. Fishbein and Ajzen, 1975 in Dubinsky/Loken	Single item scale 7 point Likert.
Normative beliefs. Refer to one's beliefs that certain individuals, groups, or institutions think he or she should perform a given behavior. Fishbein and Ajzen, 1975 in Dubinsky/Loken	13 referents were used and respondents were asked to answer on a 7 point Likert scale whether they they thaught they (the referents) taught they should perform the behavior of interest.
Role conflict and role ambiguity. Individual's view of their role and responsibilities of their job. (L. Ferrell , Fl)	Rizzo, House, and Lirtzman (1970) 6-item scale.
4. *INDIVIDUAL'S VALUES AND BELIEFS*	
Values. Ferrell & Gresham	
Religiousness. Marta dis.	Marta's Scale' 98
Deontological evaluations are individual's evaluations of the inherent rightness or wrongness of behavior. Cherry dis. **Teleological evaluations**. Cherry.	Vittell's '86 approach modified Scale derived from Fishbein and Ajzen'75 elicitation procedure 7 point Likert scale in Cherry dis.
Personal Moral Obligation. Feelings about personal moral obligations. Flannery.	3/7 point statements developed by Flannery specific for the case scenario used.

Table 50 (continued)

5. KNOWLEDGE	
Knowledge. Ferrell & Gresham	
Professional knowledge. (HPR, ER) **- Engineering knowledge** **- Engineering ethics knowledge**	# of eng. Course ethics course (yes/no)
Life experiences. (Bommer'87)	
6. **RESPONSIBILITY FOR CONSEQUENCES**	
Behavioral beliefs are a person's salient beliefs that performing a given behavior will lead to a certain outcome (or consequences) that may be positive or negative. Fishbein and Ajzen, 1975 in Dubinsky/Loken	Behaviors were generated and respondents were asked to rate on 7 point Likert scale.
Outcome evaluations. Goodness or badness of outcome of ethical/unethical behavior. Dubinsky/Loken	Respondents were asked to evaluate how good or bad each outcome was on a 7 point scale.
Financial cost. Flannery.	Two statements with 7 point Likert scale for the case in question.
Attitude toward the behavior refers to an individual's judgment concerning whether engaging in a certain behavior is good or bad. The more favorably one evaluates performing a particular behavior, the more likely the person intends to perform that behavior. Fishbein and Ajzen, 1975 in Dubinsky/Loken	Evaluative semantic differential scales using 7 point Likert scale. Fishbein and Ajzen, 1980.
Intentions. Subjective likelihood that individual will engage in behavior. Dubinsky/Loken, Ferrell and Gresham	Respondents were asked how likely it was that they would engage in each behavior 7 point scale. Scale used by Fritsche and Becker in Cherry dis.
7. DEMOGRAPHICS	
Demogrphics (Bommer '87)	Age, gender, education level data

Table 51 Organizational Factors

Professional/Legal Environment Factors (Organizational Factors)	**Instrument**
Instrumental climate/Organization's ethical climate. Respondents' perception of the ethical dimension of their organizational culture. In Flannery dis.	Victor and Cullen '88. Each item measures an organizations' instrumentality orientation (i.e., self-interest is the dominant criterion).
Corporate ethical values. A composite of individual ethical values of managers and both the formal and informal policies on ethics of the organization. Marta dis. Valentine dis.	Hunt, 9). 5/7 item Likert scale. The high Wood and Chonko CEV scale (198er the score the more ethical the environment.
Ethical environment. (Peer ethical behavior). The extent to which norms support ethical conduct, the extent to which ethical behavior is rewarded, the extent to which organizational leaders act as models of ethical conduct. And the extent to which employees are obedient and supportive of ethical behavior. In Valentine dis.	Trevino's scale'98
Professional codes. Ferrell and Gresham	
Corporate policy. Ferrell and Gresham	
Rewards/punishment. Ferrell and Gresham	
Corporate culture. Bommer	
Corporate goals. Bommer	
Codes of conduct. Bommer	
Licensing requirements. Bommer	
Stated policy. Bommer	
Responsibility for consequences. How culture defines responsibility for consequences. The culture may serve to diffuse responsibility for consequences of action by promoting external definitions of responsibility based on formal role definitions, hierarchy, and authority jurisdictions. Trevino	
Normative structure. Collective norms about what is and what is not appropriate behavior Shared values and goals of organizations' members. Trevino	
Obedience to authority. Degree to which company's culture demands obedience to authority. Trevino	

Table 52 Problem Characteristics

Problem Characteristics	Instrument
Problem's Level of Moral Intensity Components of Moral Intensity Jones, 1991). Magnitude of Consequences. The magnitude of consequences of the moral issue is defined as the sum of the harms (or benefits) done to victims (or beneficiaries of the moral act in question. Social Consensus. The social consensus of the moral issue is defined as the degree of social agreement that a proposed act is evil (or good). Probability of Effect. The probability of effect of the moral act in question is a joint function of the probability that the act in question will actually take place and the act in question will actually cause the harm (benefit) predicted. Temporal Immediacy. The temporal immediacy of the moral issue is the length of time between present and the onset of consequences of the moral act in question (shorter length of time implies greater immediacy). Proximity. The proximity of the moral issue is the feeling of nearness (social, cultural, psychological, or physical) that the moral agent has for victims (beneficiaries) of the evil (beneficial) act in question. Concentration of Effect. The concentration of effect of the moral act is an inverse function of the number of people affected by an act of given magnitude.	Scale, developed by Barnett, Brown, and Bass (1999) consists of 24 items in a semantic differential format (for components 1-5).

Table 53 Team Characteristics

Team Characteristics	Instrument
Team's level of engineering knowledge	# of major courses
Team's level of engineering ethics knowledge	Engineering ethics course (yes/no) Other ethics courses
Team structure	
Team work ability	Professional developer
Peer compliance motivation	
Life experience	Professional work experience (yes/no, no. of years)

Table 54 Personal Environment Factors

Personal Environment	Instrument
Peer Group (Bommer)	
Family (Bommer)	
Differential association (Ferrell and Gresham)	
Role set configuration (Ferrell and Gresham)	
Referent others (Trevino)	

APPENDIX F

VARIABLES IN ETHICAL DECISION MAKING

A number of authors have proposed a variety of theoretical ethical decision-making models. With regards to empirical studies related to ethical decision-making business literature shows that the variables that affect the ethical decision-making process fall into two primary categories. The first category includes variables associated with the individual decision-maker and the second consists of variables that define the situation in which the individual makes decisions. In 1994 Ford and Richardson published a comprehensive review of the empirical literature related to ethical beliefs and decision making (Ford and Richardson, 1994). A review of the empirical literature of Ford and Richardson on individual factors is presented in Table 55 and a review of situational variables is presented in, Table 56. Those variables that are shown in italics are included in this research.

Table 55 Demographic, Socio-Economic, and Personal Variables

Individual Variable	Study	Finding
Personal Attributes		
Religion	Hegarty and Sims (1978, 1979) McNichols and Zimmerer (1985) Kidwell et al. (1987)	Not significant Strong religious beliefs associated with negative attitude toward the acceptability of behaviors. No relationship between denomination or church attendance & perceptions of what is ethical.
Nationality	 Hegarty and Sims (1978, 1979) Becker and Fritzsche (1987)	Non-U.S. citizens were more unethical. French managers believe more strongly in the efficacy of codes of conduct. Not significant. U.S. managers tended to provide higher ethically ratings. No difference between managers from S. Africa and Australia.
Sex	Whipple and Swards (1992) White and Rhodeback (1992) Abratt et al. (1992) Hegarty and Sims (1978, 1979) Browning and Zabriske (1983) Beltramini (1984) Chonko and Hunt (1985) Dubinsky and Levin (1985) McNichols and Zimmerer (1985)	 Not significant. Not significant. Females more concerned with ethical issues. Males saw fewer ethical problems than females. Not significant. Not significant. Males and females differed only in 1 of 17 items. Females exhibited higher levels of ethical behavior. Females less likely to be company loyal in an ethically questionable environment. Not significant. Females more ethical than men. No difference in 3 of 4 ethical indices. Females more critical of ethical issues than males counterparts.
Age	Kidwell et al. (1987) Ferrel and Skinner (1988) Jones and Gautschi (1988) Callan (1992) Ruegger and King (1992) Serwinek (1992) Whipple and Swords (1992) Browining and Zabriskie (1983), Stevens (1984), Kidwell et al. (1987), Izraeli (1988), Jones and Gautschi (1988)	Younger managers had a more ethical viewpoint than older managers. Not significant. Not significant. Not significant. Weak significance on 2 of 14 items. Not significant. Older students were more critical. Older workers had stricter interpretation of ethical standards.

Table 54 (continued)

Educational & Employment Background		
Type of Education		
	Hawkins and Cocanougher (1972)	Business majors more tolerant of
	Goodman and Crawford (1974)	questionable practices.
	Dubinsky and Ingram (1984)	Not significant.
	Beltramini et al. (1984)	Not significant.
	Chonko and Hunt (1985)	Business majors more concerned
	McNichols and Zimmerer (1985)	with ethical issues than other
	Laczniak and Inderrieden (1987)	majors.
	Stevens et al. (1989)	Technical majors more ethical than
		were non-technical majors.
Years of Education		Not significant.
	Browning and Zabriskie (1983)	Technical vs. Non-technical
	Dubinsky and Ingram (1984)	education had no effect.
	Kidwell et al. (1987)	Few differences in the views of
	Jones and Gautschi (1988)	managers, business students,
		attorneys, and law students.
	Lane et al. (1988)	
		Managers with higher education
	Serwinek (1992)	viewed gifts as unethical.
	Goodman and Crawford (1974)	Not significant.
Employment	Arlow and Urlich (1980)	Not significant.
		Graduate degreed respondents
	Dubinsky and Gwin (1981)	were less likely than were
		undergraduates to exhibit loyalty
	Stevens (1984)	response.
	Stevens et al. (1989)	Statistical differences on only 4 of
	Dubinsky and Ingram (1984)	12 items.
	Kidwell et al. (1987)	
Years of Employment	Callan (1992)	Not significant.
		Not significant.
	Serwinek (1992)	Executives more ethical than
		students.
		Purchasing managers see more
		questionable business practices
		than do sales managers.
		Executives more ethical than
		students.
		Not significant.
		Not significant.
		Those with more years employed
		tended to exhibit more ethical
		responses.
		Length of service not related to
		ethical values.
		Not significant.

Table 54 (continued)

Personality, Beliefs & Values		
Machiavellian	Hegarty and Sims (1978, 1979) Singhapakdi and Vitell (1990) Verbeke et al. (1996) Bass et al. (1999)	High Machiavellian associated with unethical behavior. High Machiavellian managers perceived ethical problems as less serious and were less likely to take action. The higher people score on the Mach-scale, the lower the ethicality of their decision making is. Highly Machiavellian people are less ethical.
Neuroticism, Extroversion and Value Orientation	Hegarty and Sims (1978, 1979)	Neuroticism, extroversion and political orientation not significant. Economic orientation associated with unethical behavior.
Locus of Control	Hegarty and Sims (1978, 1979) Zahra (1989) Trevino and Youngblood (1990) Bass et al. (1999)	Not significant. External LOC managers perceived organizational politics as ethical. Persons with higher external locus of control behaved less ethically. External locus of control was not significantly associated with ethical judgments or ethical behavior.
Role Conflict and Ambiguity	Dubinsky and Ingram (1984)	Not significant.
Acceptance of Authority	Ferrell and Skinner (1988)	Not significant.
Idealism	Forsyth (1980-81) Forsyth and Pope (1984) Barnett et al. (1994) Bass et al (1999)	Highly idealistic people regarded the questionable acts as more unethical.

Table 56 Situational Variables

Situational Variables	Study	Findings
Referent Groups		
Peer Group Influence	Zey-Ferrell et al. (1979) Zey-Ferrell and Ferrell (1982) Izraeli (1988) Pratt and McLaughlin (1989) Dubinsky and Loken (1989) Zey-Ferrell et al. (1979)	Perceptions of peers' behavior influenced unethical behavior more than respondents' own beliefs. Inter-organizational referent groups less likely to influence behavior. What peers do was the best predictor of ethical behavior. Students more sensitive to their professors' beliefs as ethical benchmark than peer beliefs. Intenders more likely to feel pressure from referents especially top management and supervisors. Not significant. Mixed results.
Top Management Influence	Zey-Ferrell and Ferrell (1982) Akaah and Riordan (1989) Murphy et al.(1992)	Absence of top management actions against unethical behavior resulted in stronger approval of questionable practices. Actions of top managers had minimal influence on organizational ethical behavior. Rewarding unethical behavior increases unethical behavior.
Rewards and Sanctions	Hegarty and Sims (1978) Fritzsche and Becker (1983) Hunt et al. (1984) Laczniak and Inderrieden (1987)	Severe consequences lead to actions that are perceived to be supported by top management. Top management actions reduce unethical behavior. Mixed discipline leads to ethical behavior.
Codes of Conduct	Hegarty and Sims (1979) Hunt et al. (1984) Chonko and Hunt (1985) Laczniak and Inderieden (1987) Ferrell and Skinner (1988) Akaah and Riordan (1989) Singhapakdi and Vitell (1990) Murphy et al. (1992) Weeks and Nantel (1992)	Codes of conduct were positively related to ethical behavior. Not significant. Codes affect managers' perception of the extent of ethical problems. Codes + sanctions leads to more ethical behavior. Enforced codes associated with higher levels of ethical behavior for data subcontractors & research firms, but not corporate researchers. Not significant. Ethical policy determines extent to which sales executives see ethical problems. Weak support. Well-communicated code of ethics related to ethical sales force behavior.

Table 56 (continued)

Type of Ethical Conflict	Fritsche and Baker (1983) Weber (1990)	Rejected hypothesis that managerial behavior was invariant across types of ethical problems. Dilemma type affected moral reasoning of managers.
Organizational Factors Organization Effects	Victor and Cullen (1987) Ferrell and Skinner (1988) Akaah and Riordan (1989) Akaah (1992) Delaney and Sockell (1992) Verbeke et al. (1996) Ferrell (1996) Fritzsche (2000)	Significant differences in the ethical climate of four sample populations. More formalization associated with ethical decisions. Centralization related to higher perceived ethical behavior in research firms. Results suggest that healthier ethical environment leads to strong ethical stands. Strong identity with the organization associated with higher ethical behavior. Organizational warmth associated with unethical behavior. Ethics training has a positive effect on ethical behavior. The more ethical the climate, the more ethical the person's decision will be. The longer people stay within a company, the more ethical the climate will be. Ethics training has a positive effect. Not significant. Most respondents stated they would take the ethical path. The one exception involved bribery where respondents were equally likely to make or withhold payment.
Organization Size	Browning and Zabriske (1983) Weber (1990) Murphy et al. (1992)	Larger firms respondents more accepting of gifts and favors from ex-suppliers. Relationship between organization size & level of moral reasoning. Moral judgment varied by size.
Organizational Level	Chonko and Hunt (1865) Posner and Schmidt (1987) Izraeli (1988) Akaah and Riordan (1989) Delaney and Sockell (1992) Mitchell et al.(1992)	Higher level managers less likely to see ethical problems. Lower level managers were more pessimistic concerning the ethical character of their organizations. Not significant. Not significant. Lower level managers perceived greater need to be unethical to get ahead than upper level managers. Knowledge of ethical problems and perceived seriousness of ethical problems was influenced by level in the hierarchy.
Organizational Structure	Robertson and Anderson (1989) Verbeke et al. (1996)	Organizational structure affects ethical decision making. Two dimensions of the structure: the control system and the intensity of competition of the market in which the organization operates have an effect on ethical decision making. In behavior-control oriented organization the decision making will be more ethical than in an outcome-based oriented organization.

Table 56 (continued)

Industry Factors		
Industry Type	Donoff and Tankersley (1975-76)	Significant perceptual differences among retailers toward the actions taken in purchase conflict situations.
	Laczniak and Inderrieden (1987)	No difference in respondents working public vs. private organizations.
	Akaah and Riordan (1989	Not significant.
Business Competitiveness	Hegarty and Sims (1978)	Increased competition resulted in unethical behavior.
	Dubinsky and Ingram (1984)	No relationship between increased competitiveness and unethical behavior.
	Robertson and Anderson (1989)	The intensity of competition of the market in which the organization operates have an effect on ethical decision making.

In 2000 Loe, Ferrell and Mansfield updated the work of Richardson and Ford. Table 54 and Table 55 entries with dates after 1994 come from Loe *et al.* study.

The most comprehensively examined variables associated with individuals include gender, moral philosophy, education, and work experience, while culture and climate, codes of ethics, awareness, rewards and sanctions, and “significant others” represent organizational factors.

Loe *et al.* summarized the findings across the studies and found the bulk of the studies either determined no significant gender differences or found females to be more ethically sensitive than males. In addition moral philosophy was found to be related to ethical decision making where individuals may decide upon using different philosophies based on work experience or industry practice. Several studies explored education and work experience; however results were mixed, some studies indicated that higher educational levels are associated with greater ethical sensitivity, other studies found that education and experience have negligible or no effects. These mixed results suggest that there is no clear understanding of the role of education and experience in ethical decision making. Only one study found technical majors tending to be more ethical than non-technical majors (Chonko and Hunt,1985). The majority of the studies revealed that codes of ethics influence ethical decision making and assist in raising the general level of awareness of ethical issues. Further, several studies show overwhelming support for the influence of peers in ethical decision making.

All of the above studies concentrated on individuals, business majors, and the major measurement instrument used was a survey.

APPENDIX G

RECRUITMENT FLYER

Evaluation of the Decision Making Process that Individuals and Teams in Engineering Make When Solving Ethical Dilemmas Study

The University Of Pittsburgh Department Of Industrial Engineering is conducting a research study to develop and validate an ethical decision making model for engineering and methodology for conducting observations of certain engineering student outcomes. These outcomes include assessing students' ability to function on teams; identify, formulate, and solve problems, and understand professional and ethical responsibilities.

For this reason, we would like to videotape engineering students working in a team environment or individually solving engineering ethics cases problems. We are asking you if you would allow us to video tape you as you are working on the cases. All activity associated with completing the work must be done in the B84-E lab so that you may be videotaped.

In addition to being video taped you will be asked to complete four other instruments: the Defining Issues Test (DIT) that measures the level of cognitive moral development, the Ethical

Self-Efficacy Test that examines individual's perceptions regarding their job skills, abilities and confidence in their job, and a Short Demographic Survey.

We will provide you with a computer and printer along with any equipment/software associated with the lab. In addition, we ask that if you worked on a team you complete a team you take the Team Developer survey at the conclusion of the lab. This is web-based software that will take 15 to 20 minutes to complete.

There are no foreseeable risks associated with this project, nor are there any direct benefits to you. The major potential risk is a breach of confidentiality, but everything possible will be done to protect your privacy. To reduce the likelihood of a breach of confidentiality, all researchers have been thoroughly trained to maintain your privacy and have completed a confidentiality agreement. Your relationship with the University of Pittsburgh will not be affected by your participation in this study or your actions on the video tape(s). For your participation, each team member will receive $65 for approximately 3.5 hrs of work upon conclusion of the project. The videotapes will be considered confidential, and the results will be kept under lock and key. Your participation is voluntary. You may withdraw from this project at any time; however, if you work on a team the entire team will be considered withdrawn from the project and the payment will be prorated.

This study is being conducted by Dr. Besterfield-Sacre and Ms. Ewa Rudnicka. If you have any questions, please do not hesitate to contact Dr. Besterfield-Sacre at 412-624-9836 or via email mbsacre@engr.pitt.edu; or Ewa Rudnicka at 724-836-7485 or via e-mail rudnicka@pitt.edu.

APPENDIX H

CASE 1 AND CASE 2

Case 1

The Price is Right

XYZ orders 5000 custom made parts from ABC for one of its products. When the order is originally made ABC indicates it will charge $75 per part. This cost is based in part on the cost of materials. After the agreement is completed, but before production of the part begins, ABC engineer Christine Carsten determines that a much less expensive metal alloy can be used while only slightly compromising the integrity of the part. Using the less expensive alloy would cut ABC's costs by $18 a part.

Christine brings this to the attention of ABC's Vernon Waller, who authorized the sales agreement with XYZ. Vernon asks, "How would anyone know the difference?" Christine replies, "Probably no one would unless they were looking for a difference and did a fair amount of testing. In most cases the performance will be virtually the same -- although some parts might not last quite as long." Vernon says, "Great, Christine, you've just made a bundle for ABC." Puzzled, Christine replies, "But shouldn't you tell XYZ about the change?" "Why?" Vernon asks, "The basic idea is to satisfy the customer with good quality parts, and you've just said we will. So what's the problem?"

The problem, Christine thinks to herself, is that the customer isn't getting what was promised. Further, even if XYZ would be satisfied with the different part, shouldn't it be given the opportunity to decide if it finds the change acceptable -- and to benefit from lowered cost?

Christine shares her further thoughts with Vernon. He replies, "I just don't agree, Christine. This is business, not engineering. XYZ will be a satisfied customer, and we'll be a satisfied supplier. We're not in the business of giving away money, you know."

Christine decides there is nothing further for her to do. The less expensive part is produced. As the shipment is prepared to be sent to XYZ, Christine is asked to sign a report verifying that the specifications for the part have been met. As she looks over the details she notices that the original composition of the metal is listed rather than the cheaper alloy.

Christine refuses to sign the report. However, Vernon persuades her fellow engineer, John Richards, to sign it.

Case 2 Carter Racing

"What should we do?"

John Carter was not sure, but his brother and partner, Fred Carter, was on the phone and needed a decision. Should they run in the race or not? It had been a successful season so far, but the Pocono race was important because of the prize money and TV exposure it promised. This first year had been hard because the team was trying to make a name for itself. They had run a lot of small races to get this shot at the bigtime. A successful outing could mean more sponsors, a chance to start making some profits for a change, and the luxury of racing only the major events. But if they suffered another engine failure on national television. . . .

Just thinking about the team's engine problems made John wince. They had blown the engine seven times in twenty-four outings this season with various degrees of damage to the engine and car. No one could figure out why. It took a lot of sponsor money to replace a $20,000 racing engine, and the wasted entry fees were no small matter either. John and Fred had everything they owned riding on Carter Racing. This season had to be a success.

Paul Edwards, the engine mechanic, was guessing the engine problem was related to ambient air temperature. He argued that when it was cold the different expansion rates for the head and block were damaging the head gasket and causing the engine failures. It was below freezing last night, which meant a cold morning for starting the race.

Tom Burns, the chief mechanic, did not agree with Paul's "gut feeling" and had data to support his position (see Exhibit 1). He pointed out that gasket failures had occurred at all temperatures, which meant temperature was not the issue. Tom has been racing for twenty years and believed that luck was an important element in success. He had argued this view when he and John discussed the problem last week: "In racing, you are pushing the limits of what is known. You cannot expect to have everything under control. If you want to win, you have to take risks. Everybody in racing knows it. The drivers have their lives on the line, I have a career that hangs on every race, and you guys have got every dime tied up in the business. That's the thrill, beating the odds and winning." Last night over dinner he had added to this argument forcefully with what he called Burns' First Law of Racing: "Nobody ever won a race sitting in the pits."

John, Fred and Tom had discussed Carter Racing's situation the previous evening. This first season was a success from a racing standpoint, with the team's car finishing in the top five in 12 of the 15 races it completed. As a result, the sponsorship offers critical to the team's business success were starting to come in. A big break had come two weeks ago after the Dunham race, where the team scored its fourth first-place finish. Goodstone Tire had finally decided Carter Racing deserved its sponsorship at Pocono—worth a much needed $40,000—and was considering a full season contract for next year if the team's car finished in the top five in this race. The Goodstone sponsorship was for a million a year, plus incentives. John and Fred had gotten a favorable response from Goodstone's Racing Program Director last week when they presented their plans for next season, but it was clear that his support depended on the visibility they generated in this race.

"John, we only have another hour to decide," Fred said over the phone. "If we withdraw now, we can get back half the $15,000 entry and try to recoup some of our losses next season. We will lose Goodstone, they'll want $25,000 of their money back, and we end up the season $50,000 in the hole. If we run and finish in the top five, we have Goodstone in our pocket and can add another car next season. You know as well as I do, however, that if we run and lose another engine, we are back at square one next season. We will lose the tire sponsorship and a blown engine is going to lose us the oil contract. No oil company wants a national TV audience to see a smoker being dragged off the track with their name plastered all over it. The oil sponsorship is $500,000 that we cannot live without. Think about it—call Paul and Tom if you want—but I need a decision in an hour."

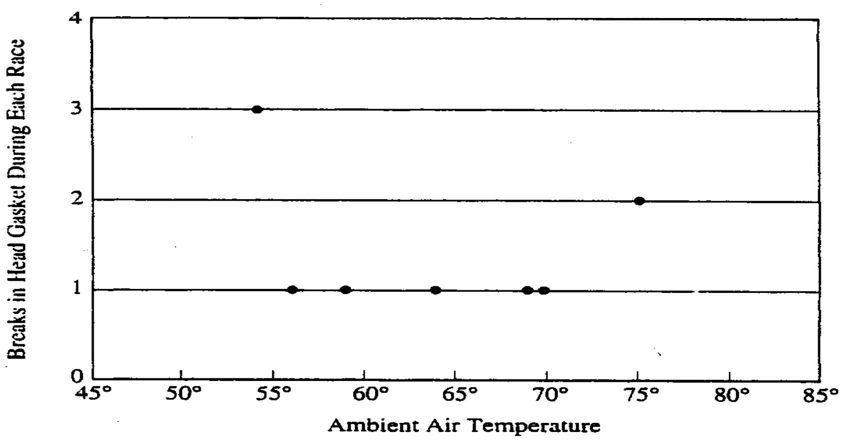
John hung up the phone and looked out the window at the crisp, fall sky. The temperature sign across the street flashed "40 DEGREES AT 9:23 AM."

EXHIBIT 1
NOTE FROM TOM BURNS

John,

I got the data on the gasket failures from Paul. We have run 24 races this season with temperatures at race time ranging from 53 to 82 degrees. Paul had a good idea in suggesting we look into this, but as you can see, this is not our problem. I tested the data for a correlation between temperature and gasket failures and found no relationship.

Relationship Between Temperature and Gasket Failures[1]



In comparison with some of the other teams, we have done extremely well this season. We have finished 62.5% of the races, and when we finished we were in the top five 80% of the time. I am not happy with the engine problems, but I will take the four first-place finishes and 50% rate of finishing in the money[2] over seven engines any day. If we continue to run like this, we will have our pick of sponsors.

Tom

1. Each point is for a single race. A gasket can have multiple breaks, any of which may produce an engine failure.
2. The top five finishers in a race are "in the money."

"Get Paul Edwards for me." John was calling to get his engine mechanic's opinion on whether they should run. The data Tom put together indicated that temperature was not the problem, but John wanted to get Paul's direct assessment.

Paul Edwards was a classic "gas station mechanic." His fingernails were permanently blackened by grease and his coveralls never stayed clean for more than two minutes on Saturday mornings. He had been knocking around the professional circuit for ten years after dropping out of school at sixteen to follow drag racing. He lacked the sophisticated engineering training that was getting more common in racing, but he did know racing engines.

John had discussed the gasket problem with Paul two days ago. As he waited for Paul to come to the phone, he reflected on their previous conversation. Paul was a man of few words and was not given to overstatement. "The way I see it, the turbo-pressure during warm-up—in conjunction with the different expansion rates for the head and block—is doing a number on us," was about the extent of what he had to say on the problem. It was his personal opinion on the cause of the engine failures: he would never represent it as anything else.

It was the same story John had heard twenty times, but it did not match Tom's data. "Paul, we have chewed this over before. How do you know this is the problem?

When we ran at Riverside the temperature was 75 degrees. and we still lost the gasket and engine."

"I am not sure what happened at Riverside," Paul had replied. "I am not sure that temperature is the problem, but it is the only thing I can figure out. It is definitely the gaskets that are blowing out and causing the engine to go."

Part of Carter Racing's success was due to a unique turbo-charging system that Tom and John had developed. They had come up with a new head design that allowed them to get more turbo pressure to the engine while maintaining fuel consumption at a fairly constant level. By casting the head and turbo bodies in a high-strength aircraft alloy, they had also saved almost fifty pounds of weight. The alloy they were using was not as temperature sensitive as the material in the engine block, but the head gasket should be able to handle the different expansion rates.

John could hear the sounds of race day in the background as Paul approached the phone. "Hello John," he said, obviously excited. "The Goodstone coveralls just got here. We are talking some fine threads. No sew-on patches from these guys. The logo on the back and our names are stitched right into the material. I guess this means we get to keep'em. Course, I got some grease on mine already, so they probably won't want 'em back anyway."

"I'm glad you like them," John said. "I need to get some information from you. What are we doing about the gasket failure business?"

"The car is set to go. We have been using a different seating procedure since Slippery Rock and had no problems for two races. Tom says the Goodstone deal is set as long as we finish in the money today. The guys in the shop want this bad. Goostone is a class act. They can make us the number one team on the circuit if they decide to take us on."

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