# "Mind the Gaps": An Empirical Approach to Engineering Ethics, 1997-2001[a,b]

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**ABSTRACT:** *A survey on ethical issues in engineering was administered over a five-year period to Stanford engineering students and practicing engineers. Analysis of its results strongly suggests that important disconnects exist between the education of engineering students regarding ethical issues in engineering on the one hand, and the realities of contemporary engineering practice on the other. Two noteworthy consequences of these gaps are that the views of engineering students differ substantially over what makes an issue an ethical issue, while practicing engineers exhibit significant disagreement over what is the most important non-technical aspect of being a responsible engineering professional in contemporary society. These divergences impede the recognition of ethical issues and of specific moral responsibilities of engineers in concrete professional practice. It is argued that the use of suitably refined and probing surveys of engineering students and practicing engineers about ethical issues in engineering is an important although neglected empirical approach to the study of engineering ethics. Such an approach can enhance the prevailing case study method and combat over-tidy theoretical-analytical approaches to the subject.*

a. When a train arrives at a station in the London Underground, a public announcement cautions passengers to "mind the gap", i.e. heed the space between the station platform and the carriage while entering or exiting.

b. An early draft of this paper was presented at the International Conference on Ethics in Engineering and Computer Science, Case Western Reserve University, Cleveland, Ohio, March 21-23, 1999.

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## I. Preface

Since emerging in earnest in the 1970s, the scholarly literature and teaching of engineering ethics have been dominated by two approaches to the subject: case studies of often dramatic real-life episodes authored by academics and participant engineers, and theoretical analyses of concepts, codes, and principles held to be central to ethical assessment of engineering conduct and practice. Noteworthy case studies include those of DeGeorge,[1] Boisjoly,[2] and Parnas,[3] while Martin and Schinzinger,[4] Alpern,[5] and Davis[6] have authored influential theoretical-analytical works.[c] While the case study approach is partly empirical in character, in what follows I illustrate a different kind of empirical approach to engineering ethics, one anchored in anthropological ethical inquiry and incorporating critical reflection on findings derived therefrom.

## II. Introduction

In alternate years I offer an undergraduate seminar, E131 ("Ethical Issues in Engineering"), in the Stanford University School of Engineering. At the beginning of the first class meeting, students are asked to complete the pertinent part of a two-part questionnaire on ethical issues in engineering.[d] In addition, each student eventually admitted into the class must recruit at least six Stanford engineering students not in the class and at least three practicing engineers outside academia to fill out the respective pertinent parts of the same questionnaire. The completed forms are retrieved by class members who turn in tabulated summaries of responses to the short-answer survey questions by the end of the second week of class. The following week a class session is devoted to discussion of the aggregated responses to the short-answer survey questions, and to critical commentaries by class members on the most interesting answers their recruits gave to the two questions each member had to devise and add to the questionnaire, one to each part.[e]

The goal in designing the questionnaire was to generate information that could, if taken on board, enhance engineering ethics teaching and learning. Specifically, I sought a well-grounded sense of both the expectations regarding matters in engineering ethics that engineering students bring to such a class and, based on the experiences of practicing engineers, what current engineering students are likely to encounter along

c. These two categories are by no means mutually exclusive. Some scholars have adopted a hybrid approach – see, e.g., ref. 7 – in which more general theoretical conclusions are extracted from analysis of concrete case studies. "Descriptive case study" and "theoretical-analytical study" are Weberian "ideal types" that can be thought of as points located at the opposite ends of a spectrum. Since a number of primarily descriptive engineering-ethics case studies have a theoretical-analytical dimension, and some primarily theoretical-analytical engineering-ethics studies make reference to one or more concrete cases to illustrate or test their conclusions, such studies can be situated at various intermediary points on the spectrum, depending on their respective characters.

d. The most recent version of the questionnaire is reproduced in Appendix 1.

e. The instructions to students for submitting summaries of responses to the short-answer questions and for preparing short presentations on responses given to student-designed questions are reproduced in Appendix 2.

engineering ethics lines in their future work lives. This material is pedagogically relevant because how an engineering ethics course is designed and taught should, presumably, reflect the mind sets future engineers bring to the course about its subject matter, as well as the experiences and opinions of former engineering students regarding ethical issues encountered in their careers. Hopefully the findings reported below will prove useful to engineering educators concerned with possible disconnects between actual ethics-related expectations, experiences, and opinions *of* engineering students and practicing engineers, and assumptions *about* these phenomena made by engineering ethics course instructors and other individuals responsible for enhancing engineering education.

The two-part questionnaire – Part I for students, Part II for practicing engineers – contains some questions calling for short, readily aggregatable responses and others designed to elicit longer, free-form answers not amenable to easy aggregation. The following discussion focuses primarily on short-answer questions in both parts. Comprehensive discussion of responses to the survey's long-answer questions is beyond the scope of this paper and is limited here to only two items.

## III. The Survey

The survey questionnaire on which this paper is based was completed at the outset of the initial class meetings of E 131 on April 2, 1997, March 30, 1999, and April 3, 2001, while recruits completed it outside of class within the first two weeks of the course. Three groups of respondents were involved each year:

- **Si:** Stanford students, mostly undergraduate engineering majors, who came to the first class session and immediately filled out in the classroom Part I of the questionnaire.
- **Sii:** Stanford students, virtually all engineering majors, who subsequently filled out Part I of the questionnaire outside of class at the request of the members of Si who were accepted into the seminar.
- **P:** Practicing engineers who subsequently filled out Part II of the questionnaire at the request of the members of Si who were accepted into the class.

A draft survey instrument was designed and first administered in 1993, then given again in revised forms in 1994 and 1995. It assumed its present form in 1997 and has remained virtually unchanged since.[f]

I am not a professional survey designer and none of the administered versions was scientifically pre-tested. As the composition of the respondent groups makes clear, the survey was not given to a random sample of Stanford engineering students or practicing engineers. Further, the results obtained have not been subjected to sophisticated statistical analysis. Lack of these desirable features notwithstanding, the results obtained are illuminating and invite more detailed exploration of anthropological engineering ethics, a domain of engineering-ethical inquiry virtually

f. The only difference between the 1997 version of the survey and the 1999 and 2001 version is that the former did not ask practicing-engineer respondents to specify their sex.

*terra incognita*. A methodological point worth noting is that the results obtained from groups Si and Sii were deliberately kept separate. This permitted determination of whether the responses of the groups of self-selected engineering students who came to the first day of class differed markedly from those of the groups of engineering students not in the class who subsequently filled out the survey at the request of class members. As it turned out, the response patterns for the Si and Sii groups were strikingly similar.

## IV. Basic Respondent Data and Aggregated Responses to Short-Answer Questions[g]

### A. Engineering Students

In 1997, 1999, and 2001, the two groups of engineering student respondents – Si and Sii – resembled each other to quite high degrees as regards their gender profiles and the percentages of their members who indicated intentions to become practicing engineers.[h]

**S4**[i] Sex

| | | **Male** | **Female**[j] | **NoAnsr** |
|---|---|---|---|---|
| | 2001 | 36 (61%) | 23 (39%) | 0 |
| **Si** | 1999 | 35 (69.2%) | 16 (30.8%) | 1 |
| | 1997 | 40 (63.5%) | 23 (36.5%) | 1 |
| Group | | | | |
| | 2001 | 125 (68.3%) | 58 (31.7%) | 0 |
| **Sii** | 1999 | 112 (70%) | 48 (30%) | 0 |
| | 1997 | 118 (66.3%) | 60 (33.7%) | 0 |

g. By "short-answer questions" I mean those that called on respondents to answer by circling "Yes," "No," "No Opinion," or "No Answer," or the number or short phrase from among those given that best expressed their views. "Long-answer questions" invited respondents to compose individualized answers to the questions given. Although some respondents answered some long-answer questions in a word or two, most composed answers two or three sentences long.

h. The figures given for questions S4 through S24 reflect only the responses of students who identified themselves on the survey forms as engineering majors. They do not include the responses of the 20 non-engineering majors who came to the first class meetings and filled out the questionnaire. For each question, the percentages in parentheses are based only on the responses of those who answered the question and expressed an opinion on it. Responses of "No Answer," "No Opinion," and "Not Applicable" did not enter into calculation of the percentages.

i. Survey items are cited by letter-number combinations, e.g., S4 and P8. The letter indicates the part of the questionnaire being referenced – "S" for Student, "P" for Practitioner – and the number indicates the item being referred to in the part of the survey referenced by the immediately preceding letter. Thus, "S4" refers to the fourth item in the student part of the questionnaire.

j. The percentage of females among declared Stanford undergraduate engineering majors was 29.53% in 1996-97, 27.66 in 1998-99, and 25.98% in October 2001.[8] Thus, in each of the three survey years, the percentage of students in my engineering ethics class who were female was somewhat higher than the percentage of Stanford undergraduate engineering majors who were female. However, a few of the females in the engineering ethics class were not engineering majors. It is safe to say, therefore, that the representation of female engineering majors in my engineering ethics class was roughly the same as that of females among all Stanford undergraduate engineering majors.

**S5.** "Do you intend to become a practicing engineer?"

| | | | **Yes** | **No** |
|---|---|---|---|---|
| | | 2001 | 47 (79.7%) | 12 (20.3%) |
| | **Si** | 1999 | 43 (82.7%) | 9 (17.3%) |
| | | 1997 | 58 (90.6%) | 6 (9.4%) |
| Group | | | | |
| | | 2001 | 135 (73.8%) | 48 (26.2%) |
| | **Sii** | 1999 | 116 (72.5%) | 44 (27.5%) |
| | | 1997 | 142 (79.8%) | 36 (20.2%) |

After requesting their respective majors, years of study, nationalities, and career intentions,[k] the intending engineers were asked:

**S6**: "Do you expect to be faced with any ethical issues or conflicts in your engineering career?"

| | | **Yes** | **No** | **NoOp** | **NoAnsr**[l] |
|---|---|---|---|---|---|
| | 2001 | 40 (93%) | 3 (7%) | 4 | 12 |
| **Si** | 1999 | 41 (95.3%) | 2 (4.7%) | 0 | 9 |
| | 1997 | 54 (96.4%) | 2 (3.6%) | 2 | 6 |
| Group | | | | | |
| | 2001 | 102 (81%) | 24 (19%) | 9 | 48 |
| **Sii** | 1999 | 92 (83.6%) | 18 (16.4%) | 6 | 44 |
| | 1997 | 118 (85.5%) | 20 (14.5%) | 7 | 28 |

Although the extremely high "Yes" percentages for Si are surprising, the fact that these percentages proved substantial is not: these respondents constitute self-selected groups, many of whose members presumably chose voluntarily to come to the first class meeting because of, *inter alia*, belief that its subject matter, as indicated by the course title, might be pertinent to their future careers.[m] Yet, the fact that, on average, 83.4% of the Sii students who were intending engineers and ventured an opinion also answered question S6 in the affirmative strongly suggests that *the great bulk of undergraduate engineering students at Stanford who intend to become practicing engineers do in fact expect to be faced with ethical issues or conflicts during their professional engineering careers*.

The student groups were then asked:

k. In the future, it might be interesting to explore the degree to which the responses given to any of the short-answer questions vary as a function of gender, nationality, major, or stated career intentions.

l. The numbers in the "NoAnsr" column reflect the fact that a certain number of the engineering majors who filled out the questionnaire form indicated that they did not intend to become practicing engineers, hence left this question unanswered. The numbers in the "NoOp" column reflect the views of those who, although intending engineers, indicated that they did not have an opinion one way or the other about the question.

m. E131 is not a required course for Stanford engineering majors. However, all undergraduate engineering majors at Stanford must satisfy the School of Engineering's "Technology in Society Requirement" by taking at least one course that satisfies the requirement. E131 is one of about 15 specific courses that fulfill this requirement.

**S8**. "Has any engineering-related ethical issue ever been *discussed* (not just mentioned) in any of your technical engineering classes at Stanford?" (emphasis in original)

| | | | **Yes** | **No** |
|---|---|---|---|---|
| Group | **Si** | 2001 | 12 (21.4%) | 44 (78.6%) |
| | | 1999 | 11 (22%) | 39 (78%) |
| | | 1997 | 19 (37.3%) | 42 (62.7%) |
| | **Sii** | 2001 | 50 (27.3%) | 133 (72.7%) |
| | | 1999 | 59 (36.9%) | 101 (63.1%) |
| | | 1997 | 61 (34.9%) | 114 (65.1%) |

To appreciate the significance of this finding, several considerations should be kept in mind. First, question S8 refers to engineering-related ethical issues being raised in *technical engineering* classes at Stanford, not in either *non-engineering* courses, such as standard philosophy-department ethics classes typically oblivious to or uninterested in engineering ethical issues, or in *non-technical* engineering classes, such as engineering economy or high-technology entrepreneurship. Second, over the 1997-2001 period only slightly less than a third – 31.4% to be precise – of the student respondents in both groups taken together answered in the affirmative, with the average "Yes" percentage for the Sii groups being slightly higher than that for the Si groups. However, the range of the affirmative response percentages was relatively modest: between 21.4% and 37.3%. Third, in spite of casting a wide net in S8, by using the words "any" and "ever", one reason that only about a third of the engineering students responded in the affirmative probably lies in use of the phrase "…*discussed* (not just mentioned)…" That is to say, students were encouraged to answer in the negative if such an issue was *merely referred to but not explored in any detail*. Further, use of "technical" in S8 notwithstanding, when asked in S9 to indicate in what course that exposure had occurred, a number of the respondents listed *non-technical* courses taken to satisfy the Stanford School of Engineering's "Technology in Society Requirement" as the source of that exposure. The responses to S8 and S9 provide strong evidence that treatment of engineering-ethical issues is neglected or given short shrift in most technical engineering courses at Stanford.

In recent years some engineering school deans and faculty members have taken the position that if engineering ethics is to be taught to engineering students it should be done in technical engineering classes by engineer instructors, rather than in dedicated engineering ethics classes taught by non-engineers. One reason given for this preference is the belief that having engineering instructors model ethical concern for engineering students in technical engineering classes would be more effective in inducing engineering students to take engineering ethics seriously than having them take a dedicated engineering ethics class from an ethicist or other non-engineer ignorant of the realities of engineering practice. While arguably true in an ideal world, this claim is also extremely unrealistic. Since the amount of material needing to be covered in mainstream engineering courses is unlikely to contract, strong incentives to engineering faculty to alter the content of their technical courses to integrate significant

ethical content are unlikely to be offered, and the knowledge and skills needed by engineering instructors to explore such issues in a pedagogically excellent manner are neither innate nor acquired overnight, the phenomenon of engineers discussing ethical issues in technical engineering classes is likely to remain the rare exception rather than become the rule.

Nevertheless, for those apt to see glasses as half-full rather than half-empty, encouragement can be drawn from the fact that almost a third of the respondents indicated that they *had* experienced some discussion of ethical issues in at least one of their technical engineering classes, even if some of these proved to be Technology-in-Society courses. It would be interesting to probe this finding more deeply, e.g., to determine the fields of engineering in which students were most and least likely to be exposed to such discussion, and to ascertain in what kinds of courses (introductory, intermediate, or advanced), taught by what kinds of instructors (in terms of variables such as industrial experience, academic appointment, professional reputation, age, and gender) such exposure is most and least likely.

Having been asked whether they had been exposed to such discussion to date, the students were then asked:

**S10**. "Do you think it might be useful to study such issues and conflicts *as part of your engineering education*?" (emphasis in original)

| | | | **Yes** | **No** | **NoOp** | **NoAnsr** |
|---|---|---|---|---|---|---|
| Group | **Si** | 2001 | 53 (94.6%) | 3 (5.4%) | 3 | 0 |
| | | 1999 | 49 (94.2%) | 3 (5.8%) | 0 | 0 |
| | | 1997 | 63 (100%) | 0 (0.0%) | 0 | 1 |
| | **Sii** | 2001 | 145 (85.8%) | 24 (14.2%) | 11 | 3 |
| | | 1999 | 131 (87.3%) | 19 (12.7%) | 10 | 0 |
| | | 1997 | 152 (91.0%) | 15 (9.0%) | 11 | 0 |

These affirmative response percentages are extraordinarily high, notwithstanding the fact that respondents were asked whether they thought study of related ethical issues and conflicts would be useful *as part of their engineering education,* not just as frosting on the general educational cake.

In light of the responses to S8 and S10, it is not surprising to learn that Stanford engineering student respondents believe that the "undergraduate education" they have received to date has not been particularly helpful in preparing them to grapple with ethical issues which most of them believe they are likely to face in their engineering careers.

**S13**. "How much has your undergraduate education helped prepare you for coming to grips thoughtfully and effectively with engineering-ethical challenges that you might encounter in your career?"

| | | **0(not at all)** | **1(a little bit)** | **2(somewhat)** | **3(a good deal)** | **4(a great deal)** |
|---|---|---|---|---|---|---|
| **Si** | 2001 | 15 (25.4%) | 28 (47.5%) | 12 (20.3%) | 4 (6.8%) | 0 (0.0%) |
| | 1999 | 8 (15.4%) | 23 (44.2%) | 17 (32.7%) | 4 (7.7%) | 0 (0.0%) |
| | 1997 | 9 (14.1%) | 37 (57.8%) | 15 (23.4%) | 2 (3.1%) | 1 (1.6%) |
| **Sii** | 2001 | 35 (19.1%) | 51 (27.9%) | 55 (30.1%) | 32 (17.5%) | 10 (5.5%) |
| | 1999 | 37 (23.1%) | 43 (26.9%) | 53 (33.1%) | 22 (13.8%) | 5 (3.1%) |
| | 1997 | 26 (14.7%) | 59 (33.3%) | 62 (35%) | 22 (12.4%) | 8 (4.5%) |

In short, in 1997, 1999, and 2001, substantial majorities of those who attended class the first day and about half of the non-class-member recruits felt that thus far their "undergraduate education" had helped prepare them to come thoughtfully and effectively to grips with expected engineering-ethical challenges only *a little bit or not at all*. Indeed, so substantial was this perceived disconnect between expectation and education that in those three years only about 6% of the Si groups and 19% of the Sii groups felt that their education had helped prepare them *a good deal* or *a great deal* for such challenges.[n] This situation suggests that engineering ethics course instructors and other cognizant engineering educators have their work cut out for them if the fit between contemporary engineering practice and the non-technical component of undergraduate engineering education is to be significantly improved.

Encouragingly, over the same five-year period, substantial percentages of the Si and Sii groups reported that their engineering instructors had done something that suggested to them that the instructors themselves believed that taking engineering ethics seriously is *important*: 43.1% of group Si members and 47.1% of group Sii members. Even more encouraging is the fact that between 1997 and 2001 only 8.8% of the Si groups and 10.9% of the Sii groups reported that their instructors had done something that suggested to student respondents that the instructors felt that taking ethics seriously was *unimportant*.

**S15/17**. "Have any of your [School of Engineering] engineering instructors done anything that led you to conclude that they believe that taking ethics seriously is *important/unimportant* while functioning as an engineer?" (emphasis in original)

| | | | Yes | No | NoOp | NoAnsr |
|---|---|---|---|---|---|---|
| **important** | | | | | | |
| | | 2001 | 21 (35.6%) | 38 (64.4%) | 0 | 0 |
| | **Si** | 1999 | 29 (56.9%) | 22 (43.1%) | 0 | 1 |
| | | 1997 | 25 (39.1%) | 39 (60.9%) | 0 | 0 |
| Group | | | | | | |
| | | 2001 | 78 (42.9%) | 104 (57.1%) | 0 | 1 |
| | **Sii** | 1999 | 70 (43.8%) | 90 (56.2%) | 0 | 0 |
| | | 1997 | 94 (53.4%) | 82 (46.6%) | 0 | 2 |
| **unimportant** | | | | | | |
| | | 2001 | 3 (5.2%) | 55 (94.8%) | 0 | 1 |
| | **Si** | 1999 | 8 (15.7%) | 43 (84.3%) | 0 | 1 |
| | | 1997 | 4 (6.6%) | 57 (93.4%) | 0 | 3 |
| Group | | | | | | |
| | | 2001 | 14 (7.7%) | 167 (92.3%) | 0 | 2 |
| | **Sii** | 1999 | 19 (11.9%) | 140 (88.1%) | 0 | 1 |
| | | 1997 | 17 (9.7%) | 159 (90.3%) | 0 | 0 |

Additional cause for optimism can be found in the fact that in all three survey years healthy majorities of both the Si and Sii groups reported that in the course of their

n. It is striking that the percentages of the Sii group members who answered "a good deal" or "a great deal" are 2.2 to 3.6 times larger than those for the counterpart Si groups. Why this is so is unclear. Several factors could be at work, e.g., relevantly different bodies of prior course work. The survey does not permit explanation of this disparity.

engineering education at Stanford they *had* in fact received a message to the effect that there is more to being a good engineering professional than being a technical virtuoso.

**S22**. "In the course of your engineering education at SU have you ever gotten a message to the effect that *there is more to being a good engineering professional in today's society than being a state-of-the-art technical expert*?" (emphasis in original)

| | | | Yes | No | NoOp | NoAnsr |
|---|---|---|---|---|---|---|
| Group | **Si** | 2001 | 36 (63.2%) | 21 (36.8%) | 1 | 1 |
| | | 1999 | 37 (71.2%) | 15 (28.8%) | 0 | 0 |
| | | 1997 | 34 (54.8%) | 28 (45.2%) | 0 | 2 |
| | **Sii** | 2001 | 107 (59.4%) | 73 (40.6%) | 0 | 3 |
| | | 1999 | 97 (60.6%) | 63 (39.4%) | 0 | 0 |
| | | 1997 | 117 (66.1%) | 60 (33.9%) | 1 | 0 |

However, the optimism kindled by these findings must be seriously tempered by one of the most striking findings of this study: the percentages of students in both groups who reported having learned *anything specific* from their engineering instructors about what is involved in being an ethically or socially engineering professional in contemporary society are *extremely and consistently low*.

**S19**. "Have any of your engineering instructors ever conveyed anything *specific* to you about what is involved in being an ethically or socially responsible engineering professional in contemporary society?" (emphasis in original)

| | | | Yes | No | NoOp | NoAnsr |
|---|---|---|---|---|---|---|
| Group | **Si** | 2001 | 2 (3.4%) | 57 (96.6%) | 0 | 1 |
| | | 1999 | 7 (13.7%) | 44 (86.3%) | 0 | 1 |
| | | 1997 | 9 (14.3%) | 54 (85.7%) | 0 | 1 |
| | **Sii** | 2001 | 26 (14.4%) | 155 (85.6%) | 0 | 2 |
| | | 1999 | 22 (13.8%) | 137 (86.2%) | 0 | 1 |
| | | 1997 | 37 (20.8%) | 141 (79.2%) | 0 | 0 |

Thus, claims or suggestions by the engineering class instructors who made them that there is more to being a good engineering professional in today's society than being a technical virtuoso were, for the most part, generalities left floating in air. Substantive discussion of specific non-technical elements of such professionalism was extremely rare.

Finally, on the engineering student side, we come to a response set that may help explain why, as seen earlier, such high percentages of respondents in the Si and Sii groups indicated that they expected to encounter ethical issues or conflicts in their engineering careers. When asked whether they had ever been employed in an engineering-related position, e.g., a summer job, in which they had personally experienced an engineering-related deed, practice or policy that they considered morally problematic or outright wrong, about a quarter (25.2%) of the respondents reported that they had, with the range running from a seventh to a third of an Si or Sii annual cohort:

**S24**. "If you have been employed in an engineering-related position, e.g., in a summer job or internship, have you ever encountered an engineering-related deed,

practice, or policy that you considered morally questionable or wrong? (If you've never had such a position, write "NA" [not applicable].)"

| Group | | Yes | No | NoAnsr | NotApplicable[o] |
|---|---|---|---|---|---|
| **Si** | 2001 | 7 (19.4%) | 29 (80.6%) | 1 | 22 |
| | 1999 | 10 (28.6%) | 25 (71.4%) | 0 | 17 |
| | 1997 | 12 (31.6%) | 26 (68.4%) | 0 | 26 |
| **Sii** | 2001 | 16 (14.2%) | 97 (85.8%) | 3 | 67 |
| | 1999 | 33 (33%) | 67 (67%) | 0 | 53 |
| | 1997 | 28 (28.6%) | 70 (71.4%) | 1 | 61 |

Such experiences could only have inclined those so exposed to believe that they would in fact be confronted with ethical issues in their future engineering careers. Of course, factors other than summer job and internship experiences probably contributed to the high percentage of the students indicating in question S6 that they expect to be so confronted. However, the present survey neither sheds light on what those other factors are nor reveals their relative importance vis-à-vis the above mentioned employment experiences.

Student responses to the short-answer questions were examined to see if sex was a significant independent variable. Of the ten short-answer questions posed, none elicited response structures from females that differed significantly and consistently from those of males.

## B. Practicing Engineers

The other respondent group, P, consisted of practicing engineers. With this group, the center of gravity of survey questions posed and responses given shifted from future expectations to past experiences and opinions based thereupon. Almost three hundred practicing engineers completed survey forms between 1997 and 2001. The gender distribution of these respondents is as follows:

**P4**. Number and Sex

| | Total | Male | Female | NoAnsr |
|---|---|---|---|---|
| 2001 | 109 | 86 (78.9%) | 23 (21.1%) | 0 |
| 1999 | 85 | 70 (82.3%) | 14 (16.5%) | 1 (1.2%) |
| 1997[p] | 100 | ? | ? | ? |

In 2001 and 1999 the percentages of females in both engineering student groups (Si and Sii) were significantly greater than those of females in the groups of practicing engineer respondents. This may foreshadow greater gender balance in the demographics of the engineering profession in the U.S. in the future.

The recruited practitioner respondents came from a wide variety of engineering fields, were of diverse nationalities and ethnicities, and averaged 8.2 years of

o. These numbers reflect the fact that many engineering majors had not had any such positions in which such questions could arise; hence they circled the "Not Applicable" answer.

p. As stated in footnote f, the 1997 questionnaire did not ask practitioner respondents for their sex. This was first done in 1999 and continued in 2001.

experience (4.5 years for females, 9.3 for males) in 2001, 12.7 years of experience (7.1 years for females and 14 year for males) in 1999, and 12.6 years of experience in 1997.

**P5**. "Are current engineering students likely to encounter significant ethical issues in their future engineering practice?"

| | Yes | No | NoOp | NoAnsr |
|---|---|---|---|---|
| **2001** | 85 (80.2%) | 21 (19.8%) | 3 | 0 |
| **1999** | 74 (89.2%) | 9 (10.8%) | 2 | 0 |
| **1997** | 81 (84.4%) | 15 (15.6%) | 4 | 0 |

The high percentages of practitioners who answered P5 affirmatively were in line with the percentages of students who indicated in answering S6 that they expect to face such problems.[q] Given such high percentages, it is not surprising that the responding practicing engineers believed *overwhelmingly* that current engineering students should be exposed during their formal engineering education to study of ethical issues of the sort they believe current students are highly likely to encounter in their future engineering careers.

**P6**. "Should [the students] be exposed during their formal engineering education to ethical issues of the sort that they may later encounter in their professional practice?"

| | Yes | No | NoOp | NoAnsr |
|---|---|---|---|---|
| **2001** | 95 (92.2%) | 8 (7.8%) | 4 | 2 |
| **1999** | 76 (93.8%) | 5 (6.2%) | 4 | 0 |
| **1997** | 87 (92.6%) | 7 (7.4%) | 6 | 0 |

The reason why the "Yes" numbers in P5 and P6 are so high is probably complex, but practitioner responses suggest that several factors are involved. First, substantial majorities of the practitioner respondents reported knowing that ethical issues arise in engineering practice, either from their own work or from other practicing engineers whom they knew or knew about.

**P7**. "Have you ever been faced with an ethical issue in the course of your engineering practice?"

| | Yes | No |
|---|---|---|
| **2001** | 58 (53.2%) | 51 (46.8%) |
| **1999** | 61 (73.5%) | 22 (26.5%) |
| **1997** | 72 (72%) | 28 (28%) |

**P11**. "Do you know or know of any engineers who have been faced with an ethical issue in their professional practice?"

| | Yes | No | NoAnsr |
|---|---|---|---|
| **2001** | 59 (55.7%) | 47 (44.3%) | 3 |
| **1999** | 58 (69%) | 26 (31%) | 1 |
| **1997** | 65 (69.9%) | 28 (30.1%) | 7 |

Second, almost three fifths of the practicing engineers who provided an answer – those who had not faced an ethical issue in their careers did not answer – acknowledged wishing that they had been better prepared to deal thoughtfully and effectively with ethical issues encountered in their work:

q. The answers to question S6 are summarized on p. 5 **(publisher to complete when paginated.).**

**P9**. "Looking back, do you wish you had been better prepared or equipped to deal thoughtfully and effectively with the [ethical] issue at the time it confronted you?"

| | Yes | No | NoAnsr | NoOp | Other |
|---|---|---|---|---|---|
| **2001** | 24 (43.6%) | 31 (56.4%) | 47 | 6 | 2 |
| **1999** | 35 (60.3%) | 23 (39.7%) | 21 | 6 | 0 |
| **1997** | 43 (64.2%) | 24 (35.8%) | 21 | 12 | 0 |

In other words, of the practicing engineer respondents who said that they had been faced with one or more ethical issues in the course of their engineering practice, almost 57% affirmed that they wished they had been better prepared to deal effectively with them. This felt lack is not surprising, since – a third factor – most reported never having had any serious discussion of ethical or social responsibility issues in *any* of their engineering classes, *undergraduate or graduate*.

**P13**. "Were ethical or social responsibility issues ever discussed (not just mentioned) in any of your engineering classes, undergraduate or graduate?"

| | Yes | No | NoAnsr |
|---|---|---|---|
| **2001** | 52 (48.1%) | 56 (51.9%) | 1 |
| **1999** | 32 (37.6%) | 53 (62.4%) | 0 |
| **1997** | 38 (38.4%) | 61 (61.6%) | 1 |

Note that serious discussion, not mere mention, of such issues was absent from *all* engineering classes, graduate *and* undergraduate, for about 58% of the responding practicing engineers.

It would appear then that, given their experience-based view that there is a high likelihood that current engineering students will be faced with such issues at work, given the rather widespread related feeling of not being adequately prepared to come effectively to grips with such issues when they were encountered, and given the general lack of meaningful discussion of ethical issues in the engineering classes of most respondents, these judgments and experiences combined to engender virtually unanimous belief among responding engineering practitioners that such exposure should be integrated into formal engineering education. To the extent that this survey finding reflects the experiences and beliefs of practicing engineers in general, and if current pedagogical choices and curricular requirements reflect beliefs about educational priorities, then, on average, practicing engineers "in the field" apparently feel more strongly about the desirability of such integration than do most engineering faculty and engineering school deans.

The responses by the practicing engineers yielded two other surprising and encouraging findings. The image of the employed engineer as impaled on the horns of a difficult professional ethical dilemma is quite familiar. That dilemma is this: either heed one's ethical concerns about some problematic work-related engineering activity and suffer the serious job-related consequences of doing so, or disregard those concerns, act solely to serve the economic interests of the employer, and thereby violate one's conscience. However, the responses of the practicing engineers who filled out the survey questionnaire suggest that this stereotypical image of the plight of the organizationally employed engineer is quite exaggerated. For while about a sixth of the practicing engineer respondents report that one or more of their employers *had* tried to

deter them from acting or penalized them for having acted as they believed they should on ethical grounds, about five sixths reported *no such experience*. This finding warrants further probing, e.g., to see how the responses varied with engineering field and years of engineering experience.

**P17**. "Has any employer of yours ever done anything to try to *deter* you from acting (or to *penalize* you from having acted) as you believed yourself obliged to do on ethical and social responsibility grounds?" (emphasis in original)

| | Yes | No | NoAnsr | NotApplicable |
|---|---|---|---|---|
| **2001** | 15 (14.2%) | 91 (85.8%) | 1 | 2 |
| **1999** | 17 (20%) | 68 (80%) | 0 | 0 |
| **1997** | 19 (19.2%) | 80 (80.8%) | 1 | 0 |

Not only is such deterring or penalizing of engineers by their employers not the norm, *au contraire*: about two fifths of the practicing engineer respondents reported that at least one employer of theirs had actually done something to *encourage* or *reward* them for having acted as they believed they should on ethical grounds.

**P19**. "Has any employer of yours ever done anything to *encourage* you to act (or to *reward* you for having acted) as you believed yourself obliged to do on ethical or social responsibility grounds?" (emphases in original)

| | Yes | No | No Ansr | NotApplicable | NoOp |
|---|---|---|---|---|---|
| **2001** | 32 (30.2%) | 74 (69.8%) | 2 | 1 | 0 |
| **1999** | 32 (38.1%) | 52 (61.9%) | 0 | 0 | 1 |
| **1997** | 33 (34%) 6 | 4 (66%) | 3 | 0 | 0 |

This finding is surprising, consistent, and encouraging, and should be conveyed to all engineering students. Those among them who wish to avoid finding themselves in a position in which they are compelled to choose between ethically responsible professional behavior and continued employment could then shape their job search processes accordingly.

Second, just as Stanford engineering students were asked (in S22) whether they had ever gotten a message to the effect that there is more to being a good engineering professional in today's society than being a state-of-the-art technical expert, practicing engineers were asked to indicate the extent to which they held the same idea. The difference here, of course, is that whereas the students' responses were anchored, presumably, in whatever messages their engineering teachers conveyed to them about this notion, in the case of the practicing engineers the primary basis for this belief is their concrete engineering work experience.

**P21**. "To what extent do you believe that is there more to being a good engineering professional in contemporary society than being a state-of-the-art technical expert?"

| | Not at all | Very little | Somewhat | Quite a bit | Very much | NoAnsr |
|---|---|---|---|---|---|---|
| **2001** | 1 (1%) | 3 (2.7%) | 19 (17.6%) | 35 (32.4%) | 50 (46.3%) | 1 |
| **1999** | 0 (0%) | 1 (1.2%) | 9 (11%) | 30 (36.6%) | 42 (51.2%) | 3 |
| **1997** | 2 (2%) | 3 (3%) | 19 (19.2%) | 28 (28.3%) | 47 (47.5%) | 1 |

Remarkably, in 1997, 1999, and 2001 only miniscule fractions of the respondents answered "not at all" or "very little." In stark contrast, in 1997 and 2001, roughly three fourths answered "quite a bit" or "very much," while about seven eighths did so in

1999. Comparing the answers to P21 with the responses given by the two groups of engineering students to S22, the percentage of the responding practicing engineers who believe that being a good practitioner of engineering in contemporary society is *not a purely technical matter*, in other words, who believe that engineering competence (at least in the contemporary U.S.) is a *socio-technical* matter, substantially exceeds the percentage of the students who said that during their technical education at Stanford they had gotten a message to the same effect. Although, as seen above in the responses to S19, few engineering students reported learning anything specific about what it is to be an ethical and socially responsible practitioner from their engineering instructors, concrete experience as a practicing engineer seems to drive home the point about the socio-technical character of contemporary engineering competence. More generally speaking, formal engineering education apparently fails to adequately equip engineering students with the ethics background and other social skills needed to do justice to their early but superficial realization that engineering is a socio-technical endeavor requiring various non-technical competencies, something driven home much later to engineers by their concrete engineering practice. *This important gap in non-technical engineering knowledge and skill needs to be addressed upstream in the educational life cycle of future engineers, not merely lamented and adapted to downstream*.

## V. Long-Answer Questions: Contra Relativism and Reductionism

Analyzing the answers to all the long-answer questions in both parts of the survey must remain a task for another occasion. However, to give a sense of the kind of long-answer questions included in the survey and the kinds of findings they yielded, consider the answers elicited by two such items, the first directed at the engineering students, the second at their practicing engineer counterparts.

### A. Engineering Students

In teaching engineering students over the years I have often noticed substantial disagreement over whether a particular issue being discussed was a genuine ethical issue. Question S11 was designed to shed light on this situation.

**S11.** "What, as you see it, makes an issue or conflict one that falls within the domain of *ethics* (as opposed to, say, the domain of aesthetics or law)?" (emphasis in original)

Lack of a shared understanding of what makes an issue an ethical one is important because in non-obvious cases it may prevent engineers from agreeing that an ethical issue is at stake in a particular concrete situation and acting accordingly. The answer of one engineering student respondent to S11 shows how problematic this can be: "None [i.e., no ethical issues] encountered so far and therefore no thought spent on such thinking [i.e., about the criteriological question posed in S11]." But doing "such thinking" oneself and reflecting on how others answer the question posed in S11 might

be precisely what is needed for the student to recognize an ethical issue to which he or she would otherwise remain unaware.

A total of 696 Stanford engineering majors and 20 non-engineering majors in groups Si and Sii turned in survey forms in 1997, 1999, and 2001. Twenty-four engineering student respondents did not answer question S11 and 14 others provided non-committal or facetious answers, e.g., "I don't know," "Not quite sure," and "If you cover it in this class, I suppose it becomes an ethical issue." There were also about 50 miscellaneous answers, most of which were *sui generis*, and several dozen responses that were inapposite or incoherent. In the end, 592 substantive replies remained and were organized into nine categories, the first three of which subsumed almost three quarters (73%) of the responses. Brief remarks on each of the nine categories follow.

1. *Consequences/Harm*. For 194 engineering student respondents, what makes an issue an ethical one is if actions pursuant to it have or would have non-trivial effects on others, especially on their "well-being." Thus, e.g., "If an issue has direct, significant repercussions on human life and well-being, then I consider it an ethical issue." and "Ethical issues are those wherein the actions of one person affects [*sic*] the lives of other people." Of these 194 respondents, almost half (91) went further, emphasizing not consequences *per se*, but a subclass of same, viz., those that would harm, hurt, damage, or bear adversely on affected parties. Responses of this sort included, "Something where the decision can cause harm to others", "Whether or not someone is hurt in some way", and "Anything that has potentially harmful effects." Of course, some respondents who referred seemingly neutrally to 'consequences' or to parties being 'affected' by the playing out of an issue, may well have had in mind both harmful and beneficial consequences *vis-à-vis* affected parties' well-being. But, interestingly, 91 respondents saw fit to explicitly link an issue's being an ethical one to the prospect or production of consequences that harm, hurt, or damage. In so doing, they seemingly aligned themselves with the view that ethics is primarily about preventing and avoiding inflicting harm, not bestowing benefit.
2. *Morality/Morals*. For 170 respondents, what makes an issue an ethical issue is its dependence in some central way on "morality," "morals," or "moral judgment." Typical of such answers were: "All ethical issues are questions of morality, "If it conflicts with my morals", and "An issue falls within the domain of ethics if a moral judgment that is unguided by law must be passed." One problem with such responses is that respondents probably lack clear, elaborated notions of morality or morals. Hence, little or no gain in clarity of thought or decision-making is realized by anchoring the criterion for an issue's being an ethical issue on equally elusive, individually varying notions of morality or morals.
3. *Right/Wrong*: For 67 respondents what makes an issue an ethical issue is its dependence on beliefs about "right and wrong." Responses of this sort included, "If it involves the possibility of personal struggle as to its right or wrong…" and "Ethics are individual questions about what is right and wrong…" Such responses – like those in #4 and #5 below – are really answers to a quite different,

anthropological ethical question, 'What makes an issue an ethical issue *for you*?', not to the meta-ethical question, 'what is it about an issue that makes it an ethical issue?' The latter invites identification of properties of the issue itself, not properties of the individual judging it.

4. *Feelings*: For 35 respondents what makes an issue an ethical issue is the necessity of consulting one's "conscience" or "gut feelings" to determine one's position on the issue. Thus, an ethical issue is "One in which you must choose which path is fundamentally right…or good with your conscience, versus…following an arbitrary rule that will simply keep you out of jail" and "If you refer to your conscience to solve the issue then it's an ethical one." Some who cited consulting conscience or one's gut feelings were actually offering a criterion not for deciding when an issue is an ethical (as opposed to a non-ethical) issue, but rather for deciding whether a course of action is ethical or unethical, e.g., by determining whether one feels "comfortable" or "uncomfortable" about it. As in #3 above, one problem with this consult-feelings criterion is that it is really only a criterion for an issue's being an ethical one for the person doing the consulting, not for an issue's being an ethical issue on its own merits.
5. *Values*. For 27 respondents what makes an issue an ethical issue is its intimate linkage to human values, either those held by the person evaluating the issue or by a society as a whole. Responses in this category included, "Something that brings into question whether something is morally correct according to your system of values" and "Something that forces one to question their own personal values in relation to those imposed by society." Mirroring the situations in #3 and #4, since individuals' value systems vary, this gambit leaves open the possibility of x's being an ethical issue for A but not for B, as opposed to being or not being one because of its own properties.
6. *Not Determined by Law*. For 26 engineering majors what makes an issue an ethical issue is the fact that its resolution is not determined by law, and, for some of them, that the issue was open to multiple interpretations. For example, "if it's controversial enough that there's no legal influence on it (laws), then I would say that's an ethical issue" and "One that is not specifically written about in a law." A problem with this criterion is that there are clearly many putative ethical issues, e.g., abortion and euthanasia, where there *is* something in the law that governs conduct. So, being undetermined by law is not a necessary condition for an issue to be an ethical issue. Nor is it sufficient to make the undetermined issue an ethical one. Being undetermined by law is, at best, a characteristic that many but not all ethical issues have. Moreover, while an ethical issue may not be determined by law at time $T_1$, it may well come to be so determined at time $T_2$, yet the issue is no less an ethical issue for coming to be thus determined.
7. *Infringement of Rights*: Nineteen respondents held that the mark of an ethical issue is whether one or more rights is or would be infringed or put at risk in the playing out of the issue. For example, "I think anything that deals with the rights of humans or others" and "Issues that affect someone's moral rights but is [sic] not a legal right."

8. *No Clear Answer*. For 12 respondents the mark of an ethical issue is that it has no clear-cut answer, or that no definitive conclusion of 'right' or 'wrong' can be reached about it. For example, "These are issues for which there is no clear answer, such as abortion and pollution…" and "Generally if something cannot be answered with a definitive 'yes' or 'no'." Some respondents linked this lack of a clear-cut answer to the alleged fact that ethics is "subjective," about which more below.
9. *Justice*: for 11 respondents what makes an issue an ethical issue is its close linkage to justice or fairness. Thus, "Some issue of justice or fairness, particularly if it involves deception or deliberate failure to put forth info to concerned parties." A problem here is the same as that noted for the not-determined-by-law criterion: while involvement with justice may suffice to make an issue an ethical issue, not all ethical issues involve justice or fairness, so bearing on justice can't by itself be that which makes an issue an ethical issue.

Thirty respondents took an easy way out. Instead of struggling to articulate a criterion governing when an issue is properly deemed an ethical (as opposed to a non-ethical) one, they circumvented the *criteriological* challenge and resorted to simply giving *examples* of one or more putatively ethical issues, most often from engineering practice.

To sum up, for about a third of the respondents, the *consequentialists*, whether an issue is an ethical issue hinges on whether it affects human well-being. For almost three tenths, the *morality theorists*, what is decisive is whether the issue is in accord with the tenets of individual morality or morals. For about a ninth of the respondents, the *deontologists*, whether an issue is an ethical issue depends on whether the issue falls within the scope of prior, seemingly primal beliefs about what is "right" and "wrong." Among the less popular contenders, for the *intuitionists* it is a matter of whether one must consult one's feelings or conscience to make up one's mind about the issue; for the *values theorists*, whether the issue implicates human values, either in general or certain specific values; while for the *extralegalists*, whether the issue falls outside the domain of law.

One issue raised by the variety and disparity of responses to S11 is that of *ethical relativism*. Many engineering students bring to engineering ethics courses the belief that, unlike the supposedly purely objective matters of fact with which they deal precisely and effectively in their engineering studies, making ethical judgments is at bottom an inherently subjective and relativistic activity properly relegated to the domain of "fuzzy studies," i.e., the humanities and fine arts. In the absence of countervailing analysis, the divergent nature of the replies to S11 and some of the categories of responses themselves could be taken as confirming a subjective/relativistic outlook on ethics. I therefore devote considerable effort in my engineering ethics classes to refuting the facile, erroneous, and corrosive epistemological assumption of subjectivity/relativism in ethical judgment, one that some engineering students conveniently cite as a justification for disregarding or dismissing ethical conflicts in engineering practice.

## B. Practicing Engineers

As seen in the responses to S19, few engineering student respondents learned anything *specific* from their engineering instructors about what it is to be a responsible engineering professional in contemporary society. But what do their practicing engineer counterparts think about what specifically is involved in being such a professional? The responses to P22 shed useful light on this issue.

**P22**. "What is the most important *non-technical* aspect of being a responsible engineering professional in today's society?" (emphasis in original)

The responses to P22 by the 292 practicing engineers surveyed were remarkably diverse. While 13 of the 292 responses were sufficiently incoherent or complex that they proved uncategorizable, the remaining 279 were organized into 13 categories.[r] conveniently divisible into two groups: A and B.

Group A contains the four categories of responses that recurred with frequencies much greater than the others, referred to here as *consequences*, *virtues*, *communication skills*, and *interpersonal skills*.

The most frequently cited non-technical aspect of being a responsible engineering practitioner in today's society was taking into consideration the *consequences* of one's work for others. A typical response of this sort, offered by 54 respondents (19.4%), was as follows: "Having an awareness of the impact of the technology you are developing and the manufacturing processes used to bring it to production (especially important from an environmental standpoint)." While some respondents who offered this kind of answer used the word "consequences," others employed "effects," "impact," "implications" and "ramifications" to make essentially the same point.

Respondents differed, however, in the *scope* of the affected 'others' about which they believed the would-be responsible engineer should be consequentially concerned. Does that scope properly encompass only affected human beings in the engineer-agent's country, or does it also include all affected humans (regardless of country), affected non-human animals, or even the affected natural but inanimate environment? In short, there was no consensus on the geographical or temporal scope of proper consequential concern.

As with the engineering students' responses to S11, some practitioner respondents went further and indicated specifically that the responsible engineer should be most concerned about a subset of the consequences of the engineer's work: viz., those that harm or risk harming others.[s] On the other hand, a few respondents took the opposite view and focused not on avoidance or prevention of harmful consequences, but on the production of beneficial consequences. For example, one wrote that the mark of the responsible engineer was applying engineering knowledge and principles "to make a

r. One respondent failed to answer the question, another resorted to a joke ("pay taxes!"), and forty-one replies were either *sui generis* or had only one similar response, hence did not justify creation of a separate category. The total number of responses recorded was somewhat greater than 292 because, in spite of the wording of the question, some replies contained two equally weighted answers.

s. Other expressions used to make this point included "adverse" and "deleterious" consequences.

positive, non-frivolous contribution to society. By 'positive' I mean one that results in the world being a better place in which to live."

The second, almost equally popular kind of response involved *virtues*; put differently, virtuous traits. Fifty-three respondents (19%) listed possession of one or more virtuous traits as the most important non-technical aspect of being a responsible engineering professional in today's society. Among the traits cited were "honesty," "courage," "integrity," "fairness," "respect," and "loyalty" (to others and/or to the employer). These respondents appear to believe that the disposition(s) cited would lead their possessors to responsible action. Some of these respondents may also believe that attending to the consequences of one's engineering work is important, but they apparently believe that doing so is more likely to occur in those with such virtuous dispositions. Thus the latter were deemed more fundamental and important.

The third most popular response category was that of *communication skills*. Forty-one practitioners (14.7%) ventured the view that possessing these skills is the most important non-technical aspect of being a responsible engineering professional in today's society. Typical of responses subsumed in this category are the following: "[Mere] technical experts are dead ducks! Engineers need to read, write, and speak effectively" and "If you can't express yourself well, it doesn't matter how capable you are." Initially I suspected that those responding thus had misinterpreted P22 as asking for the single most important non-technical aspect of being an *effective* rather than a *responsible* engineer. But, on further examination, it became clear that at least some practitioners who offered this response actually did link possession of communication skills to being a responsible engineering professional. For example, "Communication: your technical training helps you tell the possible from the impossible and find the best solution to a problem. Your employer, your customer, even your colleagues, if they aren't closely involved with the particular project you're on, all need your services as a technical translator. You need to explain your technology in non-technical terms so they understand. I feel good communication is essential to being a responsible engineer."

This category of responses raises the question of 'communication with whom.' Some respondents who offered a 'communication skills' answer stressed good internal communication, i.e., with co-workers, including management. Others stressed good external communication, e.g., with clients and the public. A number of thoughtful responses in this category stressed that being able to communicate well with non-technical people, whether in management, the community, or government, was vitally important today for would-be responsible engineers.

The fourth most frequently expressed type of response was *interpersonal skills*. Thirty-seven respondents (13.3%) affirmed or implied that possession of good interpersonal skills was the most important non-technical aspect of being a responsible engineering professional in today's society. A number of respondents made it clear that, however closely related, they distinguished communications skills from interpersonal skills. For example: "Having good communication and interpersonal skills…These are essential for day-to-day operations at work. If issues do arise, you need these skills to effectively communicate with and influence others", "being a real

'people person' along with having good communication skills", and "having adequate social skills and the ability to communicate effectively."

Respondents who cited interpersonal skills fell into two groups. Those in the first group referred vaguely to getting along well with others, e.g., "getting along with work mates" and having good "social skills"/"people skills." Those in the second, however, made reference to some *specific* kind of interpersonal skill. Most often referred to in this connection was the ability to work well as part of a project team, but organizational skills such as the abilities to listen to and take into consideration the differing views of others, to resolve or avoid disputes, to work well with a diverse set of clients and peers, and to treat others respectfully were also mentioned. While these 'interpersonal skill' responses also seem, at least initially, to be more pertinent to being an *effective* engineering professional rather than a responsible one, once again some respondents related interpersonal skills to being a responsible engineer, either vis-à-vis society or in relation to one's fellow workers. For example, one linked the interpersonal skill of the engineer who is a good listener to sound engineering decision-making, which is sometimes closely linked to avoiding harmful consequences: "being able to view other people's ideas more objectively, as one doesn't always have the right answer as an engineer"– while another wrote of "being good with people (working well with them in a group, leading them well, treating them well, etc.)."

Group B is comprised of nine significantly less frequently instanced categories of response: ethics, responsibility, client, balance, social welfare, informing society, non-technical knowledge, user requirements, and context. None of these categories accounted for more than 6% of the responses given.

Seventeen respondents offered answers that revolved around *ethics*: having "good ethics" or "good morals," acting on the basis of one's ethics, "being ethical," "engineering ethics," "being ethical…minded," etc. Such responses reflect the belief that being an individual for whom ethics matters suffices for being a responsible engineer in today's world. Indeed, such responses often stem from the more general belief that adherence to a traditional ethical code, e.g., the Ten Commandments, enables an individual to determine the ethically proper course of action in any situation, however novel, complex, or conflictive.

Fourteen respondents responded to P22 in a circular fashion, using a phrase like "social responsibility," "responsibility to society," "taking responsibility for one's actions," or "taking responsibility for people's safety and well-being" as the most important non-technical aspect of being a responsible engineering professional in today's world.

As for the remaining seven, progressively less frequent thematic responses, the respective ideas here are, in essence, that the would-be responsible engineering professional in today's world attends to the vision and needs of the *client*,[7, t] *balances* technical and business concerns with human, social, and environmental concerns.[7] concerns herself or himself about the bearing of her or his engineering work on *societal welfare*,[7] takes pains to *inform society* about the engineering realities pertinent to sound

t. The numbers in parentheses indicate the number of replies of the kind in question.

community policy-making,[5] acquires adequate *knowledge of the non-technical 'real world'* in which engineering operates,[4] carefully attends to the *needs and requirements of end-users* of engineering products;[4] and carries out her/his work in such a way as to not become caught up in its narrow technical details but so as to be attentive to *the social context* that shapes that work and in which its fruits will be implemented.[3] Finally, 41 replies were sufficiently *sui generis* that they did not warrant separate categories.

A noteworthy lesson can be extracted from this discussion of the responses to P22. As shown above, the practicing engineers' responses were remarkably diverse and lent themselves to placement in multiple categories. But no one of these or any other categories can rightly be termed the "correct" (i.e., single most important) aspect of being a responsible engineering professional in contemporary society. Rather, there are a number of aspects, for any of which a compelling case can be made. Even though factors falling into the categories of Group A were far and away the most often cited, accounting for about two thirds (66.4%) of the 279 intelligible and categorizable responses, the diversity of responses given suggests that there is a need for engineering ethics instructors to help their students to *unpack in all its complexity the concept of being a responsible engineering professional in today's world*. In so doing, one or two aspects or facets of the concept should not be allowed to stand in for the entire complex of its constitutive aspects. It is revealing that, although asked to provide "the most important" non-technical aspect of being a responsible engineering professional in today's society, many respondents were impelled to squeeze references to two, three, or four aspects into their answers.

Being a responsible engineering professional in today's society is a complex, demanding task. While engineering schools and the engineering profession as a whole can be faulted for having made little effort to convey to intending engineers any specific idea about what being such a professional involves, it is also intellectually irresponsible for engineering educators, including engineering ethics teachers, to allow the complex requirements of being a responsible engineering professional to be reduced to simple, unelaborated notions like 'concern for safety.' This is the important *anti-reductionist moral* that emerges from the mosaic of answers provided by the responding engineers taken as a whole. In light of this moral, perhaps the single most interesting answer to P22 given by a practicing engineer was the succinct but insightful response, "So many things!"

The engineers' diverse responses to P22 also have an implication for engineering ethics classes: the scholarly literature on engineering ethics notwithstanding, there is much more to the non-technical component of being an ethically and socially responsible engineering professional in today's society than having the courage to blow the whistle on engineering misconduct that jeopardizes public safety. Pedagogical preoccupation with whistleblowing obscures the complexity of and risks oversimplifying the manifold requirements for being a responsible engineering professional in today's society, especially in mundane everyday practice.

## VI. Summary

The engineering-ethics-related mind sets of the Stanford engineering student respondents and the engineering-ethics-related experiences and opinions of the practicing engineer respondents captured by the survey can be briefly synthesized.

Based on survey findings, Stanford engineering students bring to an engineering ethics or kindred course in which they enroll divergent and cognitively dissonant mental sets. Substantial, latent divergence of opinion exists about what makes an issue an ethical issue, something that fuels the tendency to fall back on either facile ethical relativism or traditional moral intuition uninformed by contemporary engineering realities. This divergence notwithstanding, widespread student expectation that ethical issues will arise in their future engineering careers coexists with infrequent, generally superficial exposure to engineering ethical issues in engineering classes and a high chance of encountering such issues outside the classroom. Similarly, widespread professed belief that there is more to being a good engineering professional than technical virtuosity coexists with a widespread lack of specific knowledge of what is involved in being an ethically and socially responsible engineering professional.

As for the practicing engineers, most have encountered ethical issues in their engineering careers. They have done so while working for employers who vary widely in their receptivity to engineers' attempts to make their practice conform to what they think, ethically speaking, ought to be done. The practicing engineers had little opportunity in their professional studies for learning how to come to grips with such issues, wish they had had more adequate preparation for doing so, believe that current engineering students will also be confronted by such issues and should be exposed to them in school, and exhibit deeply divergent views about what is the most important non-technical aspect of being an ethical and socially responsible engineering professional in today's society.

This shared epistemological fragmentation and the substantial mismatch between engineering student expectation and practicing engineer experience regarding ethics on the one hand, and the weak ethical 'equipment' – i.e., pertinent acquired ethical knowledge, skill, and perspective – of both groups on the other, pose a major challenge to engineering ethics teachers and other engineering educators. The first step in overcoming this fragmentation and mitigating this mismatch is recognizing their existence, dimensions, and magnitudes. The above findings may be useful in realizing this goal.

## VII. Conclusion

Both the findings discussed in section IV and the conclusions drawn in section V exemplify a kind of empirical approach to engineering ethics that has rarely been pursued. While the real-life case study and theoretical-analytical approaches have been fruitful, this paper has made a case for the value of a different kind of empirically based approach to the subject, one that falls within the domain of anthropological engineering ethics. Just as theoretical analyses can illuminate discussions of specific case studies, refined and probing surveys of the views of engineering students and practitioners can be exploited to shed light on problematic assumptions that shape classroom discussion of ethical issues in engineering and related downstream practitioner behavior.

**APPENDIX 1**
E 131
**Ethical Issues in Engineering**
Spring 2001
*Survey Questionnaire (Version 5.0)*

**Part I: To Be Answered By 6 Current Stanford Engineering Students**
(Y = Yes; N = No; NoOp = No Opinion)

1. Major field: _____ 2. Yr: _____ (Fr, So, Ju, Sr, Grad 1, Grad 2, Grad 3)

3. Nationality: _____ 4. Sex: _____

5. Do you intend to become a practicing engineer? (Y/N) _____ (If No, go to question 8.)

6. Do you expect to be faced with any *ethical issues or conflicts* during your engineering career? **(Y/N/NoOp)**

7. If you do, what kind of such issue or conflict do you think is most likely to confront you?

8. Has any **engineering-related** ethical issue ever been *discussed* in any of your **technical engineering courses at Stanford**? **(Y/N)** (Here "discussed" implies that something more was done with the issue than simply *mentioning* it.)

9. If so, what issue in what course?

10. Do you think it might be useful to study such issues and conflicts *as part of your engineering education*? **(Y/N/NoOp)**

11. What, as you see it, makes an issue or a conflict be one that falls within the domain of **ethics** (as opposed to, say, the domain of aesthetics or law)?

12. Assume that you will be confronted by a difficult ethical issue or conflict early on in your engineering career. What kind of background or preparation do you think might help you come to grips with such a challenge in a thoughtful, socially responsible way?

13. In your opinion, to what extent has your undergraduate education thus far helped prepare you to come thoughtfully and effectively to grips with engineering-ethical challenges that you may encounter in your career? (0 = not at all; 1 = a little bit; 2 = somewhat; 3 = a good deal; 4 = a great deal)

14. Who or what has had the most significant influence on the ethical/moral values, attitudes, ideals, or approach to making moral judgments that you would probably call upon if faced with a difficult ethical situation in engineering practice?

15. Have any of your Stanford engineering instructors said or done anything inside or outside of class that has led you to conclude they believe that taking ethical issues or social responsibility concerns seriously while functioning as an engineer is **important? (Y/N)**

16. If so, what gave you that impression?

17. Have any of your Stanford engineering instructors said or done anything inside or outside of class that has led you to conclude they believe that taking ethical or social responsibility concerns seriously while functioning as an engineer is **unimportant? (Y/N)**

18. If so, what gave you that impression?

19. Have any of your engineering instructors ever conveyed anything *specific* to you about what is involved in **being an ethical or socially responsible engineering professional in contemporary society**? (**Y/N**) (If **N**, go to question 22.)

20. What specifically have you learned from him/her/them about this idea?

21. How did you come to learn that from her/him?

22. In the course of your engineering education at Stanford have you ever gotten or picked up a message to the effect that **there is more to being a good engineering professional in today's society than being a state-of-the-art technical expert?** (**Y/N**)

23. If so, how did you come to get that or a similar message?

24. If you have been employed in an engineering-related position while a student, e.g., in a summer or part-time job, have you ever encountered an engineering-related deed, practice, or policy that you considered morally questionable or wrong? (If you have never had such a position, write "NA.") (**Y/N/NA**)

25. If you answered "Y" to #24, briefly describe what you encountered.

**To the E 131 student**: please add here as question # 26 a unique and probing question of your own design that is pertinent to the focus of this questionnaire and that you believe might prove fruitful to pose to Stanford Engineering Students.

26.

E 131
**Ethical Issues in Engineering**
Spring 2001
**Part II: To Be Answered by 3 Practicing Engineers Outside Academia**
(**Y=** yes; **N=** no; **NoOp** = No Opinion)

1. Field of engineering: _____ 2. Years of experience as a practicing engineer: _____

3. Nationality: _____ 4. Sex: _____

5. In your opinion, are students currently studying engineering likely to encounter significant ethical issues in their professional engineering practice? (**Y/N/NoOp**)

6. Should engineering students be exposed during their formal engineering education to ethical issues of the sort that they may later encounter in their professional practice? (**Y/N/NoOp**)

7. Have you ever been faced with an ethical issue in the course of your engineering practice? (**Y/N**) (If not, go to # 11)

8. If so, please describe what kind of issue it was.

9. Looking back, do you wish you had been better prepared or equipped to deal thoughtfully and effectively with the ethical issue when it confronted you? (**Y/N/NoOp**)

10. What additional background or preparation, if any, might have helped you come more thoughtfully and effectively to grips with this ethical issue?

11. Do you know or know of any engineers who have been faced in their professional practice with an ethical issue? (**Y/N**)

12. If you do, please describe the most interesting or provocative such issue of which you are aware.

13. Were ethical or social responsibility issues ever discussed (not just mentioned) in any engineering courses you took, undergraduate or graduate? (**Y/N**)

14. If so, what kind of a course was it and at what school?

15. What is the essence of your idea of an ethically and socially responsible engineering professional?

16. Who or what exercised the greatest influence on your views about being an ethically and socially responsible engineering professional? (If an individual, please indicate your relationship to her or him.)

17. Has any employer of yours ever done anything to try to **deter** you from acting (or to **penalize** you for having acted) as you believed yourself obliged to do on ethical or social responsibility grounds? (**Y/N**)

18. If yes, which was it – deter or penalize – and what happened?

19. Has any employer of yours ever done anything to **encourage** you to act (or to **reward** you for having acted) as you believed yourself obliged to do on ethical or social responsibility grounds? (**Y/N**)

20. If yes, which was it – encourage or reward – and what happened?

21. To what extent do you believe that there is more to being a good engineering professional in contemporary society than being a state-of-the-art technical expert? (Check one)

**Very much** _____
**quite a bit** _____
**somewhat** _____
**very little** _____
**not at all** _____

22. What is the most important *non-technical* aspect of being a responsible engineering professional in today's society?

23. (a) Given your experience as a practicing engineer, if you were asked to design a question to be added to this survey and to be asked of other practicing engineers in the future, what would your question be?

(b) why did you choose the question you did?

**To the E131 student**: please add here as question # 24 a unique, probing question of your own original design that is pertinent to the subject of this questionnaire and which you believe would be pertinent and might be fruitful to pose to Practicing Engineers Outside Academia.

24.

END

## APPENDIX 2
## Discussion of Survey Results in Class On Thursday, April

**1**. You **must** have the questionnaire completed anonymously by (at least) **6** SU engineering students and (at least) **3** practicing engineers working outside academia. Let me know if you need more forms or feel free to make copies. Do not wait until the last minute when you may find yourself hard pressed to secure at least 9 completed forms.

**2**. Tabulated summaries of answers received to the "Y/N/NoOp" questions on *both* parts of the questionnaire must be handed in at class on **Tuesday, April .** On Tuesday, April 20, I will distribute a sheet showing the *aggregated* responses to the short-answer questions.

**3**. On that day, each student member of the seminar will be asked to indicate:

what her/his unique, self-designed questions were,
why he/she chose those questions,
the most interesting response(s) received, and
what he/she concluded from these responses.

Each student should be prepared to hold forth for about **5 minutes**.

**4**. Please hand in at the end of class on Thursday, April :
(i) a copy of the two questions asked; and
(ii) **all survey questionnaire forms that were filled out and returned** in paper form.

## REFERENCES


1. DeGeorge, R. (1981) Ethical Responsibilities of Engineers in Large Organizations: the Pinto Case. *Business and Professional Ethics Journal* **1** (1): 1-14.
2. Boisjoly, R. (1987) Ethical Decisions: Morton Thiokol and the Space Shuttle *Challenger* Disaster. American Society of Mechanical Engineers Winter Annual Meeting, Boston, Massachusetts, 87-WA/TS-4, 1-13.
3. Parnas, D. (1987) SDI: A Violation of Professional Responsibility. *Abacus* **4** (2): 46-52.
4. Martin, M. & Schinzinger, R. (1996) Engineering as Social Experimentation. In Martin, M. & Schinzinger, R. *Ethics in Engineering*, 3rd ed., McGraw-Hill, New York, 80-124.
5. Alpern, K. (1983) The Moral Responsibility of Engineers. *Business and Professional Ethics Journal* **2** (2): 39-48.
6. Davis, M. (1991) Thinking Like an Engineer: the Place of a Code of Ethics in the Practice of a Profession. *Philosophy and Public Affairs* **20** (3): 150-167.
7. McGinn, R. (1997) Optimization, Option Disclosure, and Problem Redefinition: Derivative Moral Obligations of Engineers and the Case of the Composite-Material Bicycle. *Professional Ethics* **6** (1): 5-25. Reprinted in J. R. Rowen and S. Zinaich, eds., *Ethics for the Professions* (Harcourt, 2001).
8. Data provided by the Stanford University Office of the Registrar.