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Two Years Later: A longitudinal look at the impact of engineering ethics education

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Introduction

Between accreditation requirements [1] and national reports on the future of engineering, considerable attention has been given to the need for better ethics education in the engineering curriculum [2-3]. Several publications have been written about various approaches to addressing this need (e.g. see Herkert, 2000 [4]). The current state of affairs is a wide-array of pedagogies used in undergraduate engineering education to teach ethics, ranging from direct lectures on moral philosophy, to courses based on community service, to the use of online ethics tutorials. While there is an abundance of techniques for conveying ethics education, comparatively little work has been done in assessing the impact of these techniques on students. Overall, we have a good sense of "how" to teach ethics, but are less clear on the impact it is having on our students relative to other experiences they have while in college; in part because of a lack of assessment tools.

To make matters worse, assessment is often limited to the context of the specific intervention (e.g. a single class or program) making the results less generalizable. Further, assessments are usually conducted at one point in time, or only over a single semester. An exception to this is the work done by Barry [5] who examined the impact of ethics education initiatives on students' knowledge of ethics as measured by Fundamentals of Engineering [6] examination results. And assessment efforts are usually not connected to a grounding theory of the ethical development of individuals through the college years. The result is a limited ability to separate the impact of a single intervention from other experiences that students may have during their academic careers.

To address these shortcomings, we developed the Student Engineering Ethical Development (SEED) survey. The SEED survey is the largest investigation to date of the diversity of engineering ethics pedagogies and the ethical development of engineering undergraduates in total. The goal is to explore connections between the ethics education experiences of engineering undergraduates and their ethical development, defined here as consisting of knowledge of ethics, ethical reasoning, and ethical behavior, while accounting for experiences beyond the traditional engineering curriculum [7]. In this paper we present results from a longitudinal follow-up of the SEED study. Specifically, we present descriptive results of 450 students' ethics experiences, their ethical behavior, and measures of their ethical knowledge and reasoning, including changes in these metrics over a two year period.

Methods

Our goal for the overall SEED project was to collect large scale data from a diverse set of institutions across the United States. After a thorough process of consideration, we selected 19 partner institutions for data collection sites (See [7] for a detailed description). A qualitative analysis of focus groups and interviews conducted at the partner institutions resulted in the development of the Student Engineering Ethical Development (SEED) Survey [8,9] which we further tested through "think-aloud" cognitive questioning interviews, focus groups, and online pilot testing.

Our final online SEED Survey [7] includes 152 items plus an online adaptation of the Defining Issues Test version 2 (DIT2) [10]. The DIT2 is an established instrument that assesses individuals' moral judgment. Combined, these items measure constructs of our conceptual framework including student characteristics, engagement in formal curricular and co-curricular experiences related to ethics, and ethical development (comprising knowledge of ethics, ethical reasoning, and ethical behavior). The SEED instrument was administered in Winter 2010 (to 3914 students) and again in Winter 2012 (to 450 students). Therefore, the longitudinal sample size is 450 engineering undergraduates from 16 of our total 19 partner institutions. Students recruited for the SEED longitudinal study were in their first- or second-year during the first SEED administration to increase the likelihood that respondents would still be in college two years later.

In this paper we consider four broad metrics: ethics experiences, knowledge of ethics, ethical reasoning, and ethical behavior. We asked for self-reports of the *types of ethics experiences* students had experienced prior to the survey administration. We also included items meant to measure their satisfaction with these experiences and their perceived importance. *Knowledge of ethics* was measured with five questions similar to those used for the ethics portion of the Fundamentals of Engineering examination. For *ethical reasoning* we rely on the N2 score from the Defining Issues Test [10]. The N2 measures the extent to which an individual utilizes principled reasoning in their decision-making while simultaneously avoiding reasoning based on their own personal interest. Higher values of N2 imply higher moral reasoning capacity. Lastly we measure *ethical behavior* both in terms of pro-social behavior, as measured by participation in voluntary service to others, and anti-social behavior, as measured by engagement in cheating or academic dishonesty. These specific types of behaviors were chosen because they are familiar to our sample and relatively commonplace, making them more amenable to measurement.

Sample

We limited recruitment for the follow-up study to those students who were freshmen or sophomores in the initial study (61.0% and 36.9% of the longitudinal sample, respectively). At the time of the follow-up study, these same students were predominately juniors and seniors (48.4% and 47.7% respectively). Likewise, the average age of participants was 19.2 years at the initial administration and 21.3 years at follow-up. The percentage of female students in the sample was approximately 20.4% at the initial administration, slightly higher than the national average of 18.2% reported by the American Society for Engineering Education [11].

Respondents were asked to describe the extent to which they participated in pro- and anti-social behaviors in high school as a measure of past behavior. From the initial administration, 83.6% of students reported volunteering at least a few times in high school, 39.3% reported cheating on problem sets at least a few times in high school, and 28.4% reported cheating on tests at least a few times in high school. Thus it would appear that our sample was heavily involved in pro-social behaviors (volunteering) initially but also participated to a lesser extent in anti-social behaviors (cheating).

Ethics Experiences

Students report an increase in the cumulative number of ethics learning experiences they have had between the initial and follow-up administration (Figure 1). While it is a significant increase (p<0.001), on average students report experiencing only two more ethics learning opportunities during the two years between administrations. If we subdivide these experiences into those that happen within the engineering curriculum and those happening outside, we see that the majority of ethics experiences reported by students occur within the engineering curriculum, as does the majority of increase from the initial to follow-up administration. When subdivided not by where the ethics experience occurs, but how it is delivered, we see that at the initial administration, when our respondents are first and second year students, there is approximate equivalency between the number of ethics experiences that are traditional presentations and those that are more interactive. However, at follow-up, while both types of experiences have increased, the majority of this increase comes in the form of presentations in advanced engineering courses.

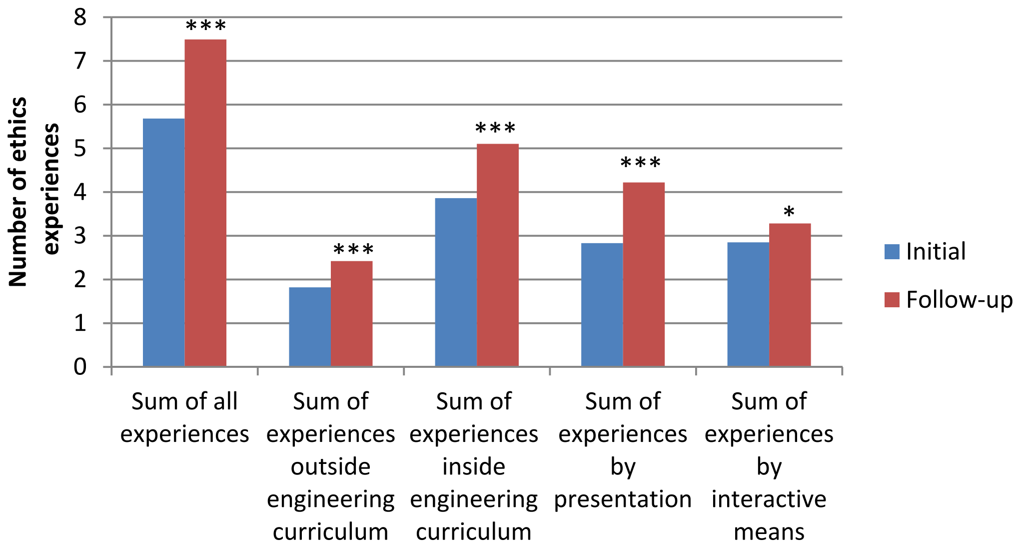

Figure 1: Sum of ethics experiences reported by participants at initial and follow-up administrations (* p≤0.05, **p≤0.01, ***p≤0.001)

As an aside, students felt that engineering ethics experiences were an important part of their education, with 82.9% and 80.3% at initial and follow-up administration reporting that learning about professional engineering ethics was important or very important. Equally large percentages report feeling satisfied or very satisfied with the quality of their education regarding professional ethics – 82.9% and 77.3% respectively. As such, there is no significant shift over the two year period. We report similar findings for the larger initial data set in Holsapple et al, 2012 [12].

Respondents were asked to indicate which of 63 possible ethics experiences they considered to be their most influential experience. At the time of the initial administration, 27.6% of students reported that a presentation by a professor in an introductory course would be their most influential while 15.6% selected a presentation by a working engineer or other quest speaker. Two years later, students still selected a lecture by a professor in an introductory course as their most influential, but now the percentage of students who had selected this option was down to 14.0%. The second most influential experience was now a lecture by a professor in an advanced engineering course (9.6%). However, if we look at those students who selected lecture by a professor in an introductory course as most influential initially and compare results for the same students at the follow-up, we see a more complex picture. Of these students, only 12% still report the lecture in an introductory course as being their most important experience, but there is no other singular experience that stands out. Instead, 47.7% of these same students now look to a curricular engineering experience of some kind as their most important and the remaining 40.2% pointing to a non-engineering or co-curricular experience. We conclude from this data that students attitudes about their most important ethics experience shift from, typically, an introductory course lecture to a much more diverse set of experiences both inside and outside the engineering curriculum.

Regardless of the experience, large numbers of respondents were likely to consider what they learned from that experience when next faced with an ethical dilemma. A total of 62.3% percent of respondents at the initial administration believed that they would consider their most influential ethics experience half or more than half the time they faced an ethical dilemma in the future. This percentage increases to 67.4% for the follow-up administration.

Knowledge and Reason

Between the initial and follow-up administrations we see small differences in the percentage of students who answer each Fundamentals of Engineering question correctly (Figure 2), but do not take these to indicate any significant differences. Likewise, when summing the total number of items answered correctly, there is no statistically significant difference in the scores for initial and follow-up (2.94 to 3.02 respectively). Interestingly, we see that scores for three of the four questions are slightly lower. As a gross measurement of knowledge, this would imply that some students are getting these questions correct on the first administration and incorrect on follow-up. We suspect that this may be indicative of some degree of guessing as these are multiple choice questions.

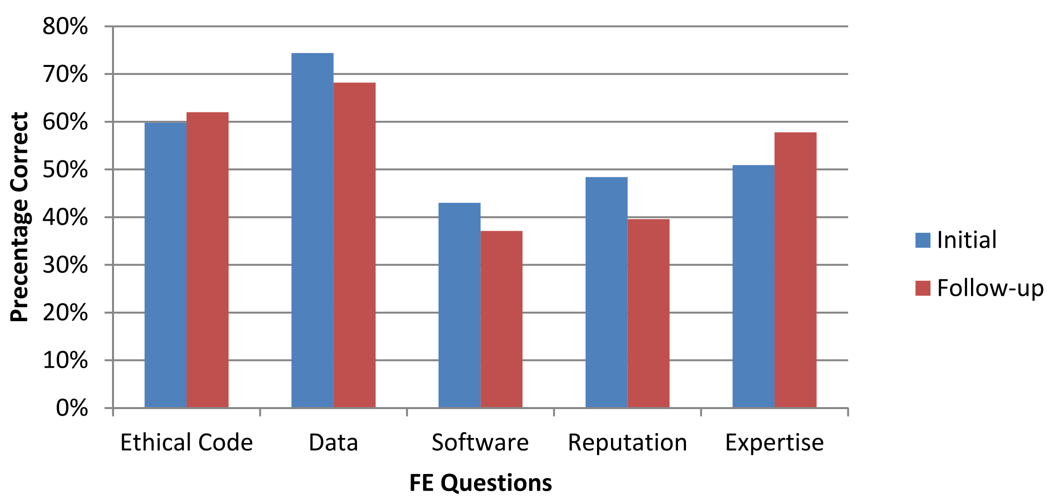

Figure 2: Percentage of correct responses to FE style ethics questions (no differences are statistically significant)

Perhaps the largest change in scores between initial and follow-up comes from the moral reasoning scores. Initially the average N2 score was 32.98 which would place the first and second year students in this study at the national norm for someone with junior standing in college [13]. Two years later, the average N2 score for this sample increased to 38.18, two points higher than the national norm for a senior in college. This 5.2 point increase was significant ($p<0.001$) and represents an effect size of $d=0.36$.

Ethical behavior

During the two year gap between the initial and follow-up administration, the extent to which students cheat increased as did the extent to which they volunteer on service-based projects. As seen in Figure 3 participants reported a higher frequency of cheating at follow-up for all scenarios presented, implying that as students progress from under-class to upper-class they are more willing to engage in academic dishonesty. Overall, 64.9% of participants reported cheating at least once in college at follow up, a 14.0 % increase from the initial administration. The greatest increases appear to occur for problem sets and tests, though we also see a sizeable gain for cheating on lab reports.

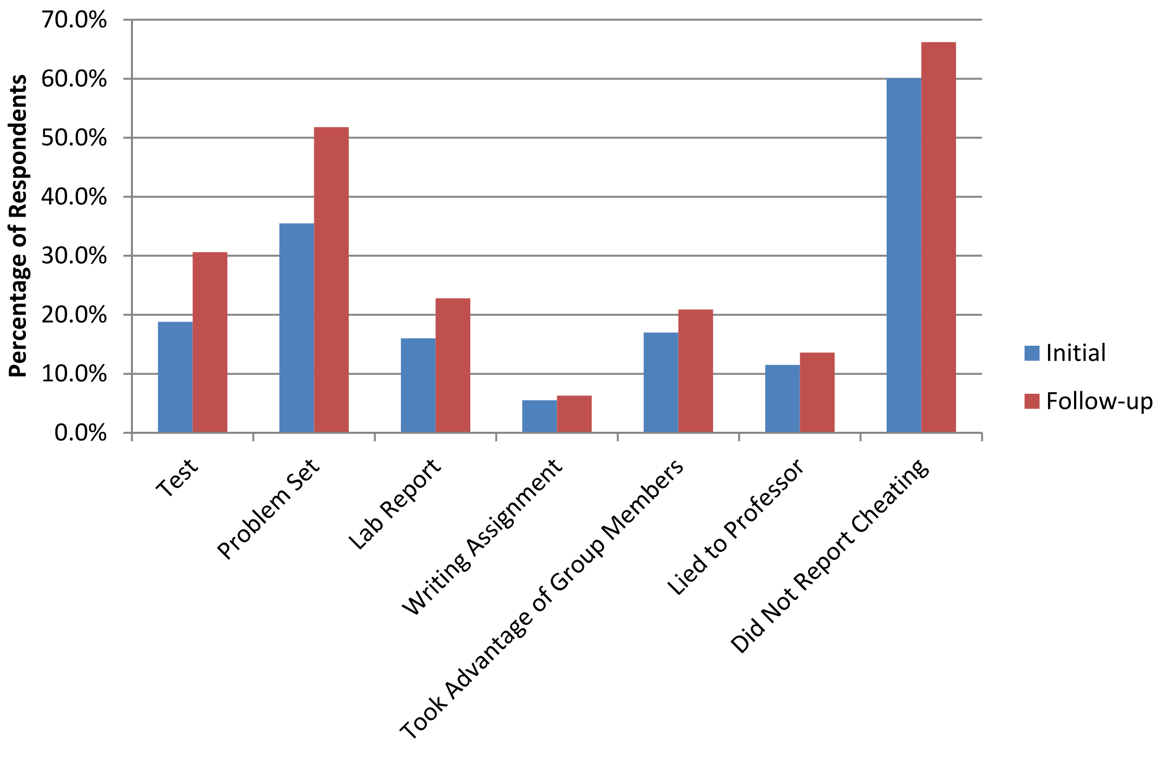

Figure 3: Percentage of respondents who reported engaging in a cheating (anti-social) behavior at least once during the academic year

A similar trend is seen with regards to pro-social behavior, defined as voluntary service meant to help others with no perceived benefit to oneself. As shown in Figure 4, compared to the initial SEED administration, there is an 11% increase in the percentage of participants volunteering in college from 50.1% to 61.1%. The largest increase in volunteerism, both in absolute numbers and proportion, is in engineering outreach programs – 42.2% at follow-up compared to 23.8% at initial administration. Another large proportional change is observed for volunteer tutoring, though it remains a relatively uncommon form of volunteerism.

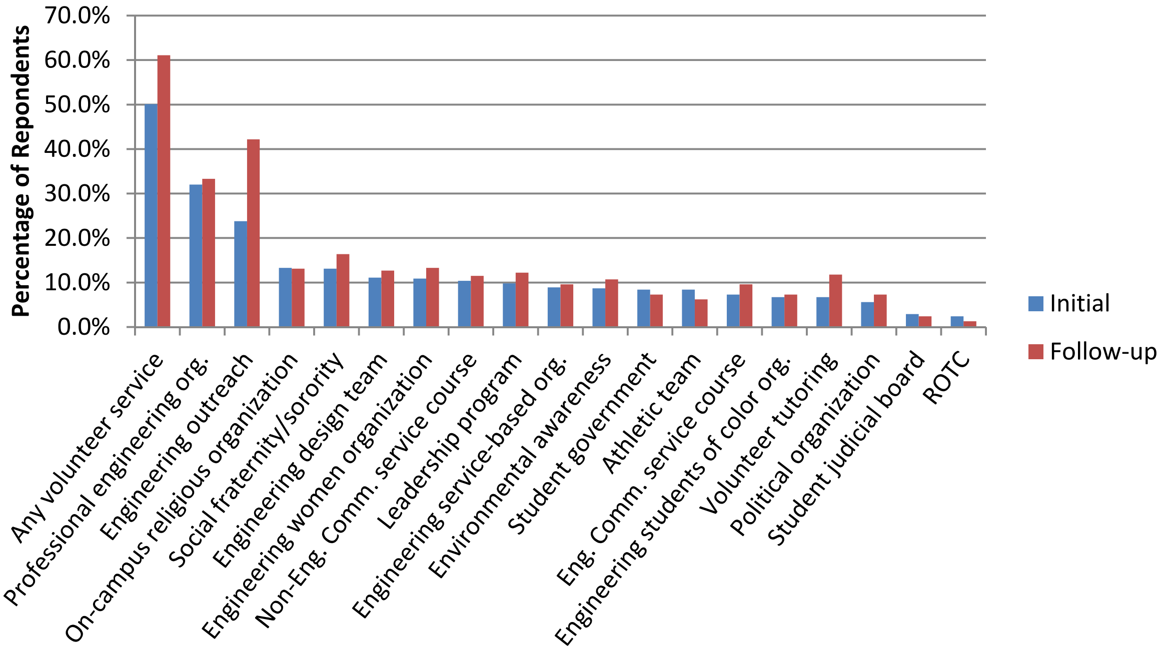

Figure 4: Percentage of respondents who reported engaging in volunteer service (pro-social)

Discussion

Overall, we arrive at varied findings for this study. Students seem to participate in more service, to engage in higher levels of ethical reasoning, and to be satisfied with their ethics experiences after 2 years of college. Simultaneously they are cheating at higher rates, making no real gains in their knowledge of ethics, and describing only moderate changes in their ethical experiences.

The lack of knowledge gains may be a consequence of the nature of ethical experiences up to the point of the survey. Though students report many ethics experiences throughout their education, focus on knowledge, particularly knowledge of codes of ethics measured by the FE examination, may not be occurring until the senior year, if at all. But even the participants who attained senior status did no better on the FE-type questions than they had as sophomores. This raises several questions. Are these students receiving instruction on codes of ethics? And if so, is this knowledge being retained? It would appear not.

If the ethics experiences reported are not impacting knowledge of ethics, why the increase in reasoning scores? Moral reasoning is known to advance naturally with age to a point [13]. Scores for participants were already higher than national norms suggest. So it may well be that the gains in moral reasoning are occurring independently of any ethics experiences students report. We cannot ignore that students' experiences both in and outside of the engineering curriculum are designed to enhance moral reasoning, though perhaps not ethical knowledge. Given the present data set, there is no way to distinguish these two possibilities. Future research could involve interviews with faculty who design or deliver traditional and non-traditional ethics experiences to assess the extent to which they emphasize reasoning versus knowledge and other ethics outcomes in their interventions.

The increase in student cheating is not a surprising finding. In prior work we have found that upper-class students report cheating more frequently than under-class students [14]. Furthermore students report more cheating despite significant gains in their moral reasoning scores. This implies that despite having an enhanced capacity for determining whether cheating is morally defensible, students are still choosing to cheat and at higher levels. It is known, however, that moral reasoning does not correlate well to ethical (or unethical) behaviors [15]. So instead we need to look at mediating factors including past behavior, a sense of obligation to avoid unethical behaviors, perceptions about the relative ease or difficulty of cheating, perceptions of the normative conditions for when someone should or should not cheat, and others. We have found in past studies that all these factors contribute to students' decisions regarding cheating. Thus, the decision to cheat is a complex combination of cognitive capacity, social norms, and personal beliefs and expectations.

A similarly complex picture exists with regard to volunteer service. Why should individuals who decide to engage in anti-social behaviors also decide to engage in the very pro-social behavior of volunteering to serve others? A cynical view might argue that students see both cheating and volunteering as ways to enhance their credentials – academic and social – in the hopes that this may lead to a higher probability of gaining an attractive job offer at graduation. Others might generate a more socially-oriented explanation in that cheating is seen as an acceptable behavior as 'sharing of homework solutions, copying lab reports, etc.' tips the odds of succeeding in a class into the favor of one's peers, much like tutoring others helps to tip the odds for the tutored. Strong direct and indirect messages about volunteerism and academic performance may also contribute to students' decisions about volunteering and cheating respectively. Or we might conclude that behaviors such as cheating and volunteering have become as commonplace as to be habitual. Habitual students would cheat as a sub-conscious first choice to succeed in a course. Likewise, students might volunteer, particularly through peer groups such as professional and social societies, not as a rational choice but because it is a habitual tendency.

We conclude that understanding the moral knowledge, reasoning, and choices of engineering students is complex. In this paper we have attempted to present preliminary results from the largest ever longitudinal study on ethical development in engineering. Our results suggest that while in some ways our students develop ethically during college, they stagnate or take steps backwards in others. Questions that have arisen include: Can we expect the modest increase in ethics experiences reported here to have a lasting impact on our students? What is the necessary level of ethics knowledge required for engineering practice, and is it being taught and retained? Are gains in moral reasoning a result of natural human development or of specific ethics experiences? How can we encourage students to participate in pro-social behaviors without likewise engaging in anti-social behaviors? If moral reasoning seems unrelated to ethical behavior, what are the underlying decision making processes students employ when it comes to ethical/unethical behavior? Should ethics interventions be designed which specifically address these decision making processes with an aim to changing students' behavioral patterns? If so, how? These and many other questions remain to be answered.

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