2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32657

Engineering Alumni Rate the Impact of Co-curricular Activities on their Ethical Development

Dr. Angela R. Bielefeldt, University of Colorado Boulder

Angela Bielefeldt is a professor at the University of Colorado Boulder in the Department of Civil, Environmental, and Architectural Engineering (CEAE) and Director for the Engineering Plus program. She has served as the Associate Chair for Undergraduate Education in the CEAE Department, as well as the ABET assessment coordinator. Professor Bielefeldt was also the faculty director of the Sustainable By Design Residential Academic Program, a living-learning community where students learned about and practice sustainability. Bielefeldt is also a licensed P.E. Professor Bielefeldt's research interests in engineering education include service-learning, sustainable engineering, social responsibility, ethics, and diversity.

Mr. Jake Walker Lewis, University of Colorado Boulder

Graduate of the University of Colorado Boulder holding a bachelor's degree in environmental engineering and a master's degree in civil engineering. Presented undergraduate research findings on ethics in co-curricular university environments in the form of a poster at the 2018 Zone IV ASEE Conference. Defended and published master's thesis examining ethics introduction in K12 STEM education in November 2019. Second co-author of the paper "Educating Civil Engineering Students about Ethics and Societal Impacts via Cocurricular Activities", published in the Journal of Professional Issues in Engineering Education and Practice and recognized as an Editor's Choice. Currently involved with research regarding ethics in engineering education with Dr. Angela Bielefeldt. Preparing to submit three papers regarding ethics in education for the 2020 ASEE Annual Conference & Exposition.

Dr. Madeline Polmear, University of Florida

Madeline Polmear is a postdoctoral researcher in the Department of Civil and Coastal Engineering at the University of Florida. She completed her B.S. in environmental engineering, M.S. in civil engineering, and Ph.D. in civil engineering at the University of Colorado Boulder. Her research focuses on bridging technical and nontechnical competencies to support the professional preparation and ethical responsibility of engineering students.

Dr. Daniel Knight, University of Colorado Boulder

Daniel W. Knight is the Program Assessment and Research Associate at Design Center (DC) Colorado in CU's Department of Mechanical Engineering at the College of Engineering and Applied Science. He holds a B.A. in psychology from Louisiana State University, an M.S. degree in industrial/organizational psychology and a Ph.D. degree in education, both from the University of Tennessee. Dr. Knight's research interests are in the areas of K-12, program evaluation and teamwork practices in engineering education. His current duties include assessment, team development, outreach and education research for DC Colorado's hands-on initiatives.

Dr. Chris Swan, Tufts University

Chris Swan is Dean of Undergraduate Education for the School of Engineering and an associate professor in the Civil and Environmental Engineering department at Tufts University. He has additional appointments in the Jonathan M. Tisch College of Civic Life and the Center for Engineering Education and Outreach at Tufts. His current engineering education research interests focus on community engagement, service-based projects and examining whether an entrepreneurial mindset can be used to further engineering education innovations. He also does research on the development of sustainable materials management (SMM) strategies.

Engineering Alumni Rate the Impact of Extracurricular Activities on their Ethical Development

Abstract

This research explored the extent to which alumni felt that extracurricular activities during college impacted their ethical knowledge, reasoning, and/or behavior. The research utilized a mixed methods approach, with both an online survey and interviews. The survey asked "To what extent did co-curricular activities and/or informal learning experiences during college impact your ethical knowledge, reasoning, or behavior?" Alumni rated 9 activities based on a scale of: did not participate, involved but no impact (0), small impact (1), moderate impact (2), large impact (3). Among the engineering alumni, most activities were rated as having a moderate impact on ethical development among those who had participated, on average: volunteer activity (n 105, avg 1.9), fraternity/sorority (n 33, avg. 1.9), internship or co-op (n 100, avg. 1.8), design groups (n 90, avg 1.8), undergraduate research (n 75, avg 1.8), engineering service group (n 37, avg 1.7). Activities that averaged a smaller impact included: sports (n 74, avg 1.4), professional society (n 90, avg 1.3), and honor society (n 40, avg 0.8). Follow-up interviews were conducted with 14 alumni who described specific examples of ethical development from engineering service groups, internships, undergraduate research, the mini Baja team, the Society of Women Engineers, local community service / volunteer activities, student government, leading a non-engineering student group, a fraternity, and informal conversations with engineering professors. Some also noted that they participated in various co-curricular activities (e.g. professional societies) but did not believe they contributed to their ethical knowledge, skills, or reasoning. The perspectives of working engineers can help faculty advisors of extracurricular activities to integrate ethics education in these contexts.

Background

It is important that engineers are prepared to face ethical dilemmas in their work before they graduate from college. However, ethics instruction is a challenging task given the myriad situations that may be encountered and variability in the extent that students are motivated to learn about engineering ethics. One challenge in student motivation is the perception that ethical dilemmas are uncommon and unlikely in most engineering work. Thus, student perceptions of the quality of the ethics instruction that they received may be skewed by their lack of foresight into the future importance of these topics. A retrospective reflection of working engineers on their college ethics education can overcome this limitation and may provide perspectives that are different from students.

Ethics is one of the required learning outcomes under ABET [1]. Therefore, ethics content is taught in a variety of required courses in accredited engineering degree programs. Faculty report integrating ethics topics into a variety of different course types, teaching ethics via a variety of pedagogies, and assessing student learning with a variety of approaches [2-8]. Faculty have also described integrating ethics topics into co-curricular activities that they mentor [9-12]. However, faculty perceptions of teaching effectiveness may differ from those of students [13, 14]. These differences might be particularly large in co-curricular settings where the majority of faculty do not formally assess the extent of student learning [9, 15].

In a previous large study of ethics [16], about 4000 engineering students from 19 institutions reported their level of participation in five engineering-based and 10 non-engineering based co-curricular activities, as well as participation as a leader or in volunteer service associated with these groups. However, the extent to which the co-curricular activities may have influenced ethical knowledge, reasoning, or behavior were simply inferred based on earlier interviews [17] rather than directly rated by the students as part of the survey.

Ethical development with respect to engineering can take a variety of forms and has been classified in a variety of ways. A common model is Kohlberg's stages of moral development and measurement using the Defining Issues Test [18]. However, this preferences a particular ethical framework, and different models could be used such as the Ethics of Care [19]. Other approaches to classifying ethical development in engineering consider the cognitive sophistication and affective elements of engineering ethics. For example, the American Society of Civil Engineers (ASCE) mapped the ethical responsibilities of civil engineers outcome to Bloom's taxonomy in the cognitive domain and Krathwohl's affective domain [20]. Individuals may also develop increasing sophistication in their understanding of both microethical and macroethical issues [21], which includes a host of sub-topics such as social responsibility, social justice, and sustainability. In this work we take a broad perspective on ethical development that encompasses all of these myriad ways in which an individual may change in their knowledge, reasoning, and attitudes with respect to engineering ethics.

The logic framework behind the current study is summarized in Figure 1, derived from input-environment-output models [22, 23] and ideas in the Professional Social Responsibility Development Model [24] which was grounded in the Ethics of Care. Engineers in the workforce (right side of figure) will possess varying levels of professional ethical development. They have reached this state via different pathways. Students come into college with vastly different levels of personal ethical development due to life experience that includes family influences, formal K-12 education, and extracurricular involvement. During college, engineering ethical development occurs, catalyzed by formal education, extracurricular involvement, and broader factors such as institutional culture. Ethical development also should continue to grow in the workplace via a process of lifelong learning. Engineers may encounter different situations that cause them to draw on previous experiences and in hindsight view those experiences differently. For example, learning a framework for ethical reasoning in a required engineering ethics class that seemed unimportant at the time may be perceived as meaningful when the individual realizes its usefulness in confronting a situation in the workplace.

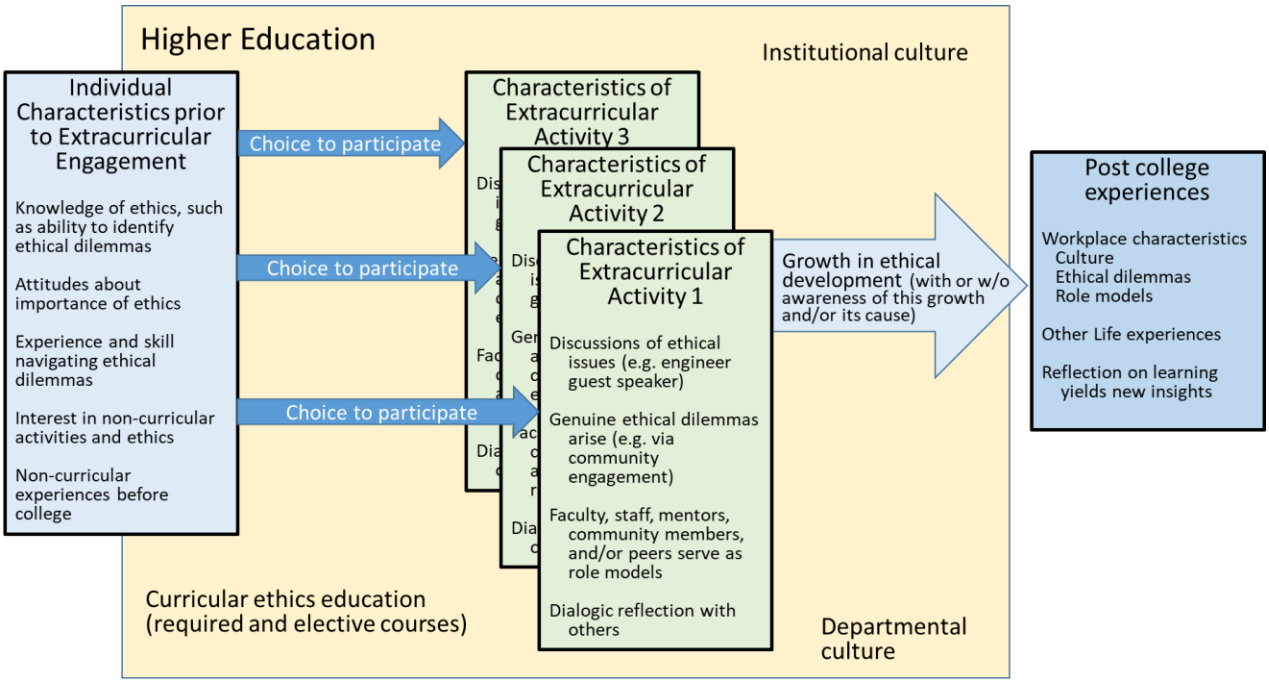

Figure 1. Visualization of how engineering ethical development occurs in engineers, highlighting the role of extracurricular activities during college in this development

The extent of engineering ethical development for each student will vary based on their personal ethical development and specific experiences. This includes the ethics content in required courses which varies across institutions and by discipline [5, 25]. Even students who took the same curriculum in required courses will evidence different levels of ethical reasoning [26]. In addition, students will take different elective courses, elect to participate in different extracurricular activities, and participate in those activities in different ways (for example, some take on leadership roles). Note that students may participate in a similar experience (such as international community service engagement) but not derive the same ethical growth from that experience [27]. Rest and Narvaez [18] stated, "both the college environment and personal predispositions appear to interact to produce measurable gains in moral judgment"; it is expected that a similar phenomenon applies to engineering ethical development.

Students voluntarily elect to participate in extracurricular, co-curricular, and informal learning experiences. Co-curricular activities are defined as those that relate to one's college major, including activities such as a student chapter of a professional society and undergraduate research. Informal learning experiences encompass both co-curricular activities and broader extracurricular activities. Extracurricular activities can include volunteer community service (e.g. homeless shelter), intramural sports, and religious groups. Note that the terms used to discuss these activities is not consistent within the literature or at institutions [28]; other studies have used descriptors including out-of-class activities and non-curricular activities. All activities in life present opportunities for learning, so all of these non-course-based activities are of interest, particularly given that ethics crosses both personal and professional spheres.

The extent that engineering students engage in various extracurricular activities has been evaluated in a number of studies [29, 30]. A variety of outcomes may result from student

involvement in informal learning settings [30, 31]. Fisher et al. [31] used a literature review to map 20 professional outcomes to 22 activities; they determined that ethics could be developed via seven activities: academic competitions, departmental groups, housing communities, media, project teams, service organizations, and student governance. They tried to validate the literature results via interviews with 10 engineers who had recent experience as direct supervisors of entry-level engineers; however, ethics was among five attributes not validated by these interviews. Alumni feedback has been used to assess a number of professional skills such as teamwork, leadership and communication [32-34]. Wankat et al. [32] found that among 99 chemical engineering (ChE) alumni survey responses, the importance of ethics was rated as very important (5, the highest) by 43%; only 4% rated the importance as 1 (unimportant) or 2. However, only 65% indicated they had sufficient opportunity to learn about ethics as undergraduate students (percentage ranked as 3 to 5 on Likert scale). When indicating where they had learned about ethics as an undergraduate student, 39 indicated the ChE seminar (unclear if this was a required or optional seminar course or just informally offered), 24 a co-op or internship, 9 ChE lab or design course, 8 non-ChE courses, and 8 extracurricular activities. The development of knowledge and skills in non-curricular activities during college is not surprising given that choice has been found to be an important component of motivation, and motivation generally results in stronger learning outcomes [35-37].

It is possible that students learn a lot from engagement in extracurricular activities but are somewhat unaware of this learning. For example, students may be motivated to play a sport like ultimate frisbee for fun. However, during this experience they may learn teamwork, interpersonal communication, and leadership skills. Given that they didn't go into this experience with a prospective mindset, will they be aware of this learning? The "four approaches to learning from experience" [38] provides a helpful framework. These four approaches are: intuitive (learning is an inevitable result of experience), incidental ("learning by chance from activities that jolt an individual into conducting a post-mortem", p. 5), retrospective (examining an experience and reaching reasoned conclusions), and prospective (planning to learn before an experience). It is expected that the ethical development that may occur when students participate in extracurricular activities is due to intuitive, incidental, or retrospective approaches. The logic in this study is that the on-the-job experiences of engineering alumni provide a 'jolt' that causes them to reflect and draw upon the ethical reasoning that they may have developed during college extracurricular activities.

Research Questions

Two research questions were explored in this study:

RQ1. To what extent do engineering alumni perceive that extracurricular activities during college impacted their ethical knowledge, reasoning, and/or behavior?

RQ2. How and why do engineering alumni perceive that extracurricular activities during college impacted their ethical knowledge, reasoning, and/or behavior?

Methods

To answer the two research questions, this research used a mixed method approach, combining quantitative data from survey items with qualitative information from semi-structured interviews.

The research reported in this paper was embedded within a larger study [5]. This research was reviewed by an Institutional Review Board (IRB) for human subjects research and deemed exempt (Protocol #15-0326).

A survey instrument was developed to answer RQ1, using many of the best practices suggested in [39]. The survey instrument was developed through a multi-step process that began with a literature review. A pilot version of the survey was tested in 2017 with a convenience sample of alumni from three institutions (public university with very high research; private university with high research; private religiously-affiliated doctoral university), and 11 responses were received. The pilot survey concluded by inviting comments about the survey itself and an invitation to provide contact information for a follow-up. Five individuals who took the pilot survey provided additional comments via email or a short phone conversation. The survey instrument was revised based on that feedback. Both the pilot survey and the final alumni survey were administered through Qualtrics.

The survey began with an informed consent statement, which explained that the research was "exploring the extent to which education on ethics and broader impacts in college prepared individuals for real world challenges in their work as engineers, computing professionals, and in related areas. We invite you to participate in this online survey as a former student at xx University who took a course related to xx." The survey first asked questions about the specific course and other courses where the alumni recalled learning about ethical issues in college (analysis of the results from this question are beyond the scope of the current study). Next the survey asked "To what extent did co-curricular activities and/or informal learning experiences during college impact your ethical knowledge, reasoning, or behavior?" Alumni rated six engineering related activities, three non-engineering related, and could add other(s). The response options provided were: did not participate, involved but no impact (0), small impact (1), moderate impact (2), large impact (3). Near the end of the survey, individuals were asked whether they might be willing to participate in an interview about how their ethics instruction as a student impacted them after graduation. The survey concluded with demographic questions: year they had taken the targeted course, year they had earned their Bachelor's degree, open-ended line to fill in the major of their Bachelor's degree, whether or not they had earned graduate degrees, types of engineering jobs, gender, and race/ethnicity. Individuals who completed the survey and opted to provide their email address received a $10 e-gift card to Amazon.

Table 1 summarizes the characteristics of the alumni who participated in the study. The research team partnered with eight faculty who taught undergraduate engineering students about ethics in a course that represented potentially exemplary ethics education (see more details in [40]). Six of these faculty taught engineering courses (including upper-division energy related elective that was taken by a number of science students in addition to engineering) and two taught non-engineering courses (a communication course and an ethics course, taken by students from all majors including engineering). These faculty taught at eight different institutions, which ranged from public to religiously-affiliated private institutions and a variety of Carnegie classifications (Bachelor's, Master's, Doctoral, R2, and R1). The partnering faculty emailed alumni from their course and invited them to participate in an online survey in spring 2018; three faculty sent additional email invitations to the survey in fall 2019 (to students presumed to have graduated fall 2018 – spring 2019). Some of the faculty indicated that they had few contact emails by

which to reach alumni who had graduated from their institution, while others had more complete contact lists (although in some cases were uncertain if the email addresses were current or not). In addition, a convenience sample of alumni from a 'control' group (not believed to have experienced exemplary ethics education) were invited to participate in the survey.

Table 1. Alumni survey participant characteristics

Institution Carnegie Type [38]	Exemplar Course	Student Majors	n	Years since graduated Median (range)
Private religiously affiliated, R2 higher research activity, very large	Engineering Ethics	Mechanical, electrical, and other engineering	57	4 (<1 to 13)
Private religiously affiliated, doctoral, medium	Senior engineering professional issues and ethics	Mechanical, biomedical, and electrical engineering	24	1 (<1 to 2)
Private religiously affiliated, Bachelor's, small	First-year engineering	General engineering	20	1 (<1 to 3)
Public R1 highest research activity, very large	Sustainability and energy	Chemical engineering; natural sciences	36	1 (<1 to 3)
Public R2, professions focus, medium	Communications	All majors	14	<1 (<1 to 1)
Public R1, very large, Southeast	Ethics	All majors	19	1 (<1 to 1)
Private Master's medium	Engineering professionalism	Civil engineering	1	1
Public Master's larger	Engineering professionalism seminar	General engineering	2	2, 5
Control: Public R1, very large	N/A	Environmental, civil, general engineering	7	7 (1 to 20)

There were 173 university alumni who responded to the survey questions about co-curricular activities at the eight exemplar institutions, and an additional seven alumni from the control institution. Because each institution was provided with a unique link to the survey, the institution of the respondent and the course they represented were known. Thus, among alumni who did not complete the demographic information and identify their major, respondents from the courses that only enrolled engineering majors were presumed to be former engineering students. In total, the responses represented 147 engineering students, primarily graduates from five institutions. There were an additional 33 responses from non-engineering students.

To conduct statistical comparisons of the data where alumni rated the extent that extracurricular activities contributed to their ethical development, non-parametric tests were conducted using IBM SPSS Statistics v. 26. The non-parametric statistics were appropriate given the response scale from no effect (0) to large effect (3). To compare responses from engineering alumni to non-engineering alumni, the Independent-Samples Mann Whitney U Test was conducted. To compare engineering alumni from different institutions the Independent-Samples Kruskal-Wallis Test was conducted first, followed by post-hoc pairwise comparisons. Given the fairly low number of respondents, a threshold of 10% likelihood of a Type I error was selected ($p < 0.1$) to infer a statistically significant difference. P values represent the asymptotic significance in a 2-sided test.

An interview phase followed the survey. On the survey, 78 individuals provided their email address indicating some level of interest in participating in an interview, but only 53 had a Bachelor's degree in engineering (some were also unknown since they neglected to respond to that item on the survey). Follow-up interviews were conducted with eight alumni who took the survey; results from six additional interviews conducted with engineering alumni from the 'control' institution are also included. Individuals were compensated with a $50 e-gift card to Amazon for participating in the interviews. The semi-structured interviews were conducted over the phone or skype by the second author and audio recorded; transcripts were created from the audio recordings assisted by Trint software. During the interview, individuals were directly asked about any extracurricular activities that they recalled introducing them to ethical or societal issues. The results are reported using pseudonyms that were assigned using a random name generator and 'clean verbatim' quotes from the transcripts.

Limitations. The first limitation to consider is that individuals were recalling impact from college experiences in the past and these recollections may be imprecise [42, 43]. In addition, subtle impacts may go unrecognized. The number of responses is small, and individuals who elected to respond to the survey may be those who placed greater value on ethics and/or had a greater connection to the instructor that emailed the survey invitation. Further, the survey instrument was not fully validated using rigorous methods [39, 44]. The majority of the survey respondents had not worked very long as engineers after graduation. Those interviewed represented a broad range of different career lengths post-graduation. Not all engineering disciplines and types of engineering work are represented among the results.

Results and Discussion

RQ1. Extent of impact

The survey results are summarized in Table 2. For all nine activity options listed on the survey, one or more individuals believed that the activity had a large impact on their ethical development. There were also one or more individuals who participated but believed that the activity had no impact on their ethical development. This indicates variability of experiences. Faculty advisors of co-curricular groups have described different levels of intentional integration of ethical issues into the groups they advise, even within the same type (e.g. multiple advisors of student chapters of the American Society of Civil Engineers) [9]. On an individual level, students who felt at an initially high level of ethical development may not have believed that participation was impactful for them personally in this regard. Or the individuals may not have been perceptive to the ethical dilemmas posed. Alternatively, the individual may have engaged in the activities in different ways (e.g. some attended the guest speaker who discussed ethical issues they encountered in the workforce, some took on leadership roles in the group).

Among former engineering students who participated, the average impact and percentage attributing the activity as having a large impact were similar across 6 activities: volunteer activity, internships, design group, research, engineering service group, and fraternity/sorority. Interestingly, among alumni from non-engineering disciplines, internships and fraternity/sorority participation were more impactful than for engineers ($p= 0.022$ and 0.063, respectively). In terms of fraternity/sororities, it may have been that non-engineering students held leadership roles or

were more involved, or given the positioning of the question on the survey the engineering alumni may have been considering impacts on their career-related ethical knowledge, reasoning, or behavior versus a more general perspective on ethical development.

Table 2. Alumni participation in non-curricular activities during college and extent that it impacted their ethical knowledge, reasoning or behavior

Group of alumni	Volunteer activity	Internship or co-op	Prof'l Society	Design group	Research	Honor society	Eng service group	Fraternity Sorority	Sports
Engineering			K.02		K.02			K.06	K.06
% participated	79	74	69	67	59	31	30	25	54
Avg impact	1.9	1.8	1.4	1.7	1.8	0.8	1.7	1.8	1.4
% no impact	10	13	24	12	14	43	12	8	20
% large impact	27	25	12	31	25	11	24	28	18
Non-Engrg		W						W	
% participated	82	55	24	NR	73	NR	NR	21	NR
Avg impact	2.0	2.3	1.6	NR	2.0	NR	NR	2.6	NR
% no impact	0	0	25	NR	0	NR	NR	0	NR
% large impact	37	50	25	NR	33	NR	NR	71	NR

NR = Data not reported if 6 or fewer participants; ^{K} = Kruskal-Wallis comparison among engineering alumni from different institutions sig. < 0.1. ^{W} = Mann-Whitney comparison between engineering and non-engineering alumni sig. < 0.1

Institution level comparisons identified differences among institutions in the impact ratings for professional societies, research, fraternities/ sororities, and sports (Table 2). Post-hoc pairwise comparisons determined that alumni from the religious doctoral institution gave lower ratings to professional society impacts on ethical development (avg. 0.7). For research, alumni from the religious bachelor's institution had higher ratings than alumni from the religious R2 institution and public R2 institution (avg. 2.3 vs. 1.6 and 1.4, respectively). For sports, the 4 alumni who attended the public R2 institution and participated in sports rated its impact on their ethical development higher (avg. 2.5) than alumni participants at the other institutions. Fraternity or sorority participation was rated as having little or no impact on the ethical development of the 3 participants from the public R1 institution (avg. 0.3).

Further research is needed to explain and explore institutional variations. Speculating, the higher rating of research at the religious bachelor's institution may be due to an exemplary ethics education experience in a first-year engineering course at that institution which primed students for ethical awareness in later research. Alternatively, it may be that research at the bachelor's institution had a greater focus on the benefits of the experience for student learning versus a more transactional approach to engineering research at the R2 institutions which focused on research outcomes over student development. Differences among the professional societies might be due to the faculty advisor and the extent they encouraged the integration of ethical issues (see [9] and [45] for examples).

RQ2. How extracurricular activities influenced ethical development

While the survey data gives an indication of perceptions that different types of co-curricular or extracurricular activities were impactful to their ethical development, the interviews provide more rich information. When individuals were asked during the interview about potentially significant co-curricular or extracurricular activities, many were unsure what that meant and asked for clarification. The interviewer provided context such as, "So a co-curricular experience

could be a club or a sorority or an honor society or even community service. Anything that's affiliated with the university but not explicitly coursework." Table 3 summarizes the co-curricular/extracurricular activities described in their interviews, with more details in the following paragraphs.

Table 3. Overview of alumni interviews

Pseudonym	Extracurricular activity discussed in interview	Survey high impact	Yrs work experience
Larry	*None*	Internship, volunteer	1
Howard	Student government	{none}	1
Calvin	Engineering with mission service group	Volunteer	1
Gene	Fraternity, informal conversations with professors	Internship, design group, volunteer, fraternity, other	2
Sophie	International medical volunteer group, local community service group	Research, prof society, service group	2
Owen	Internship	Internship, research, design group, volunteer, other	2
William	Mini Baja design club	Other	1
Roland	*None*	Internship, sports	2
Melissa	Society of Women Engineers	*NA*	20
Anne	Engineering service group	*NA*	1
Brad	Research	*NA*	8
Shane	Leadership of club	*NA*	7
Kathy	*Not really*, volunteer with campus eco center	*NA*	1
Denise	Internships	*NA*	1

NA = control institution; unable to identify individual among survey respondents

Co-curricular engineering design groups provide an opportunity for students to learn about ethics and societal issues in situations that may be fairly similar to real world engineering. William described how his involvement in the Mini Baja design competition related to ethics.

> I feel like Baja helped expose me to ethical issues as a microcosm of what's out there in the working world. … one of the big things specifically from an ethical lens that I learned from it was how much safety is important in manufacturing and manufacturing vehicles and keeping America safe and doing it efficiently, but also how easy it is to lose sight of that as the person working on the car. And how kind of important policy is and and holding to rules and standards even when it might be easier to cut corners. One of the big rules, one small example, that would be like never working on a car in the workshop alone, always having a second person there and wearing particular safety gear…. So I feel like that was my first real engineering encounter with the ethics that I could experience in the real world.

On the survey William rated engineering design groups as having a moderate impact on his ethical development. In addition to the competition guidelines and situation that may embed ethical issues, faculty advisors may be influential in these co-curricular design groups. An earlier study found that multiple faculty advisors of the same co-curricular design groups (ASCE concrete canoe) variously indicated that the experience was or was not relevant to students' ethical development [9]. Thus, perhaps the faculty advisor emphasized the importance of safety to the students participating in Mini Baja, which translated into an impact on William's ethical development. Thus, faculty advisor may want to leverage the opportunity provided by co-curricular design competition settings to call students' attention to intrinsic ethical issues.

Co-curricular engineering service groups have the potential to impact students' ethical development [15]. Calvin noted that there were some ethical issues he encountered while participating in activities with a local engineering service group at the R2 religiously affiliated institution. The group engaged in projects related to conservation and societal issues, including homelessness. His description was rather vague and did not expound on how the experience furthered his ethical development.

Anne gave a fairly detailed description of how her engagement with Engineers Without Borders (EWB) was important in her ethical development. She discussed working on a project to design an improved latrine system for sanitation at a local school, paying particular attention to privacy issues for the teenage female students and also making the structure earthquake resistant for safety. The students struggled with the project, and she noted that their professional mentors had experience with sanitation systems but not structural safety. The students came to the realization they were working outside their area of competence, a key requirement in most professional codes of ethics:

> … ultimately we realized that we weren't the engineers to be implementing this because it was likely that it would fail. And so that was a case of ethical consideration where we had to sit there and be like, honest with ourselves, like, hey, even though we are engineers that are learning how to do these really cool things and we really want to help these girls. We finally ended up just getting rid of that entire project because we just knew that we didn't have the training and we didn't have the confidence or the resources to really do a good job ….

The story indicates that better mentoring or advice from a faculty member early in the process should have reinforced the importance of ethical issues including working in their area of competence. Seeing this issue in an authentic setting was likely more impactful for the students than reading about this ethical requirement in a course, where case study examples typically seem obvious.

Another alumni, Brad, commented that he believed ethical issues were likely embedded within groups like EWB or could be included in professional societies, although he did not personally experience ethical development in those settings.

> There was, you know, the [professional engineering society] and I was involved in, but I don't remember there being any sort of like ethics [but] maybe there was more of the societal stuff. I think that there is more of like, you know, almost like in Engineers Without Borders type, you know, flavor to some of those meetings and then bringing in speakers and stuff like that. They kind of focus on the societal impacts of engineering and the right to access clean water and things like that. But ethically, I don't think there is any discussion about what are the ethics of private engineering practice or anything like that.

Similarly, Roland indicated a lack of personal ethical development in extracurricular activities, but, "I was a member of SPE, the Society of Petroleum Engineers, and AADE, the society of drilling engineers. I wasn't particularly active in those organizations. …there wasn't really a lot of ethical consideration there. …[But] I'm sure people who are more active in the SPE and AADE probably did have more of that experience."

Other interviewees also noted the potential for richer ethics learning in student professional societies. For example, Melissa responded to the question on her ethics learning through extracurricular activities:

> That actually I experienced… not a whole lot, I was involved in ASCE [American Society of

> Civil Engineers] as well as student government, and SWE [Society of Women Engineers] while I was in college. SWE would touch on discrimination and the ethical issues with discrimination. But beyond that, [ethics] didn't really come across much. It could have definitely been enforced better, particularly with ASCE and some of the professional organizations [such as] bringing in somebody from the outside and doing a talk on engineering ethics and why it's important.

It seems that a faculty advisor for professional societies could serve an important role by inviting guest speakers to specifically describe ethical issues important in their work. Integration of this topic into multiple presentations versus an explicit focus on ethics in a single presentation might be more meaningful by allowing students to see that ethical issues are common in a variety of work settings.

Undergraduate research includes a variety of ethical dimensions [12]. Faculty advisors can play an important role in bringing these issues to the attention of students. Brad briefly described how his engagement in research as an undergraduate student related to ethics:

> When I was working as an undergraduate in research there were certain things that were relayed regarding the aspects of data collection and data validation. And, this is all data that could be used and published in the literature and it needs to be ethically sourced. So there's like the ethics of research that were infused into that that research….

Although internships are not typically directly influenced by the university, these experiences can provide opportunities for students to experience ethical issues. Owen discussed his first internship experience at a commissioning firm in-depth.

> You have to go in and make sure [the projects are] done to the standards that are set not only by themselves, but by the laws of the state. …I don't know that it was so much internally keeping ethics in check, but it was making sure that all of the teams that we were working with and that we were overseeing were maintaining their ethical code …. [and] not cutting corners. And in doing that I guess it was very interesting to see how often people would try to cut a corner just to save a few dollars here, which in the long run is not what is best for the end user or the client.

He went on to describe a specific project that his company was involved in where there had been a failure and a resulting investigation. This experience led him to understand the importance of being proactively conscientious as well as being transparent.

> … every team was trying to point fingers and say, no, we didn't do it. And our team actually went forward and we said, look, here's what we know about this. Here's the information we have. So while it could have looked bad on us, … we [didn't] run away from the problem and point to others. My boss at the time actually went ahead and he said, 'hey, I don't believe this was on us. However, here's all of my documentation and any information you may need to be able to support this to get through this investigation.'

Denise also discussed multiple internship experiences during college that encompassed making wise investments of taxpayer dollars and thinking about long-term sustainability. As an environmental engineer, Denise worked for public utility and an oil and gas company. She contrasted these experiences and the ethical ramifications. She described drawing on these experiences in the context of courses such as senior design, having a better appreciation for real-world macroethical issues.

Rather than discussing a co-curricular activity that helped their ethical development, some of the alumni described extracurricular experiences that were not related to engineering. This seems to

indicate a lack of rich ethical development for these individuals in engineering-related out-of-class experiences. For example, Shane described ethical issues that he encountered while serving as the leader of a campus club, which generally revolved around budget issues and fairness; "That was certainly a learning process. I took on that role as a sophomore, having never really had to deal with a budget or having to deal with organizing a large group of people. And it was very much a learning process, learning how to not get taken advantage of…."

Howard discussed an anecdote of his involvement with student government in college, in particular issues with disclosure and transparency of their deliberations; "there was one time in particular where people didn't want the debate to get out. And so they basically like suppress the chamber and forced all nonessential members out so that they could talk without people knowing what they were discussing. And I think that called in some ethical concerns to me… It wasn't like anything super ethically violating, but I think it was just those around election season, and so people were trying to make sure that nothing bad got out about them because they were uncomfortable about their own thoughts and feelings." This experience seems to relate to issues in the engineering code of ethics that require "avoiding all conduct or practice that deceives the public" while also acknowledging issues of confidentiality (per the NSPE Code of Ethics, Professional Obligations 3 and 4 [46]).

When asked about extracurricular activities that brought up ethical issues or considerations, Sophie discussed two different volunteer service experiences. One was a group "that helps set up medical clinics in different parts of Central America" and a [local] community service club. She described the activities that she participated in with these groups but did not describe why she believed that participating in those activities was important to her ethical development.

Gene had the richest discussion of ethical development in extracurricular activities. He noted "a plethora of ethical dilemmas in fraternities". He also noted informal conversations with the instructor of his engineering ethics course and other professors.

> … a couple of friends and I were really interested in being able to conceal carry handguns on campus for self-defense… after ethics class we just hung back with [the professor] and basically asked him what he thought. And [we had] a pretty long conversation about the pros and cons. And so it was very informal. But we had a couple of professors that we really connected with like that. There's another guy… he would actually come to breakfast with us every month alone in the dorm and hang out and talk. … [And another professor] was always leading these engineering mission trips like over the summer spring break. And, you know, just being around the school, you hear about him and it was always pretty cool to see our program and stuff like that that's really ethics related…

Gene's discussion ranged from specific examples to the broader culture at his religiously-affiliated institution.

Implications, Limitations, and Future Work

In general, there appeared to be few connections between the survey ratings and the interviews. Activities that individuals indicated as having a large contribution to their ethical development on the survey were not always discussed during the interviews. For example, Larry indicated on the survey that internships and volunteer activities had a large effect on his ethical development but when asked during the interview about extracurricular activities that were impactful he

replied, “I don't think so. No, I can't remember doing anything particularly related to anything where ethical issues came up.” Earlier questions on the survey or during the interview may have primed individuals differently, such that their recall of extracurricular activities differed. The interviewer did not customize the interview to ask specifically about items highly rated in the survey; this change in the interview protocol may have yielded richer results.

On the whole, the majority of the interviews showed an interplay between the ethics education that occurred in courses and ethical development in extracurricular settings. The extracurricular settings described were generally authentic experiences and activities. In some cases, the formal ethics education in their courses preceded the experience, and therefore they were better attuned to ethical issues during their extracurricular experiences. Alternatively, the extracurricular activity preceded formal ethics education, which made them appreciate the ethical issues being discussed since they had experienced related situations. This hearkens to both the approaches to learning from experience [38] and Kolb’s experiential learning cycle [47]. One can picture a spiral of learning [47] whereby both the cognitive and affective aspects of ethical development interplay through a reinforcing loop that includes different lived experiences via co-curricular and extracurricular activities and connections to content in courses (Figure 2).

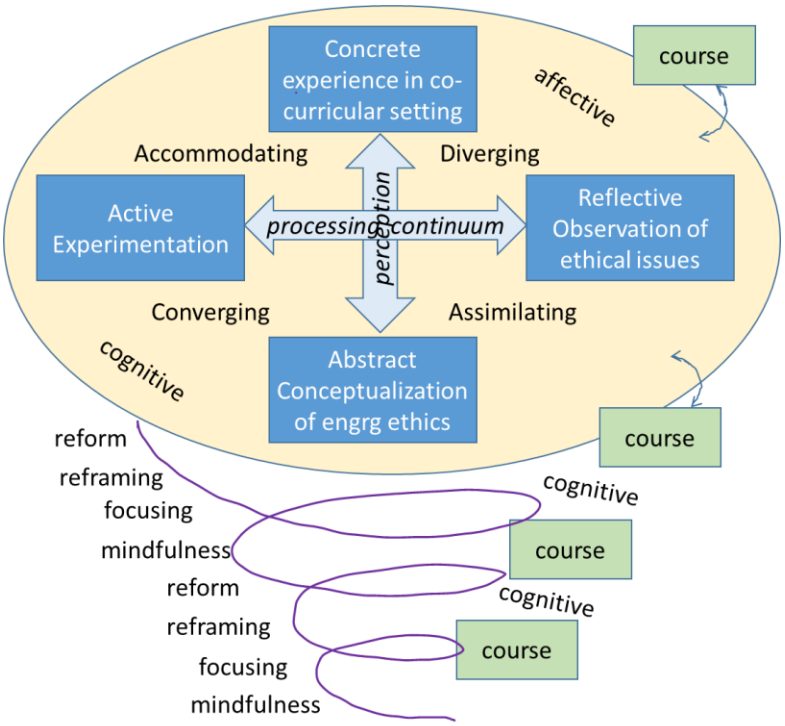

Figure 2. Conceptualization of Kolb’s experiential learning cycle / spiral which frames how co-/extra-curricular activities interact with courses resulting in ethical development

For most individuals there appeared to be a continuum between personal ethical values and professional ethics, such that their extracurricular activities did not need to be engineering-related to be relevant to their professional ethical development. None of the descriptions of ethical development during their extracurricular activities seemed very well scaffolded, presenting an opportunity to faculty mentors and advisors of these activities. This can range from

directing particular activities (e.g., bringing in a guest speaker to talk about ethical issues at a professional society meeting) to more informal facilitation of reflection via discussion. Helping students to be focus their attention (perception) and be mindful (processing) may be particularly helpful in leveraging extracurricular experiences into rich opportunities for ethical development.

While the alumni shared stories of extracurricular settings that they connected to ethical issues, most did not clearly describe how or why the experience helped further their ethical development. This is a limitation of this study which provides an incentive for further research.

Summary

The engineering alumni identified extracurricular settings that they believed were meaningful in their ethical development on both a survey and during interviews. The activities described in the interviews were generally similar to the categories on the survey. The interviews gave the sense that categories of extracurricular activities varied widely. In addition, personal dispositions seemed important in interpreting different extracurricular experiences as being meaningful to ethical development. The extracurricular activities appeared to have little to no direct ethics instruction, but rather provided rich, authentic experiences that presented a variety of ethical dilemmas. The co-curricular and extracurricular activities that engineering alumni identified as being impactful to their ethical development did not differ markedly in comparison to the perceptions of faculty [9] and engineering students [17] but reinforce the role that extracurricular experiences can play in helping to develop ethically-competent engineering professionals. Extracurricular experiences seem to help complement formal ethics education in courses. Therefore, ethics-across-the-curriculum whereby multiple courses touch on ethical issues provides a good model for interacting with out-of-class activities. Further, faculty who advise co-curricular activities could be more intentional in drawing students' attention to ethical issues in these settings via a teachable moments approach. In this way, engineering faculty can contribute to creating a culture that communicates the value and importance of ethical behavior in the engineering profession.

Acknowledgments

This material is based on work supported by the National Science Foundation under Grant #1540348, #1540341, #1540308, and #1755390. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors also thank our collaborator Nathan Canney, Ph.D., P.E., who contributed to the broader project.

References

[1] ABET. 2019. *Criteria for Accrediting Engineering Programs*. Effective for Reviews during the 2021-2021 Accreditation Cycle. ABET, Baltimore MD.

[2] National Academy of Engineering. 2016. *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs*. Washington: National Academies Press.

[3] J.L. Hess and G. Fore. 2018. "A systematic literature review of U.S. engineering ethics interventions," *Sci Eng Ethics*, vol. 24, pp. 551-583.

[4] A. Colby and W. M. Sullivan. 2008. “Ethics teaching in undergraduate engineering education,” *J. Eng. Edu*. Vo. 97 (3), pp. 327–338. https://doi.org/10 784.1002/j.2168-9830.2008.tb00982.x. 78
[5] A.R. Bielefeldt, M. Polmear, N. Canney, C. Swan, D. Knight. 2018. “Ethics education of undergraduate and graduate students in environmental engineering and related disciplines,” *Environmental Engineering Science*, vol. 35 (7), pp. 684-695. DOI 10.1089/ees.2017.0308.
[6] A.R. Bielefeldt, M. Polmear, D. Knight, C. Swan, N. Canney. 2017. “Incorporation of ethics and societal impact issues into senior capstone design courses: Results of a national survey,” *Proc. American Society for Engineering Education (ASEE) Annual Conference and Exposition*. 19 pp. https://peer.asee.org/28516
[7] A.R. Bielefeldt, M. Polmear, D. Knight, C. Swan, N. Canney. 2017. “Incorporation of ethics and societal impact issues into first year engineering courses: Results of a national survey,” *Proc. American Society for Engineering Education (ASEE) Annual Conference and Exposition*. 15 pp. https://peer.asee.org/28515
[8] A.R. Bielefeldt, M. Polmear, D. Knight, C. Swan, N. Canney. 2020. “Variations in reflections as a method for teaching and assessment of engineering ethics,” *Proc. American Society for Engineering Education (ASEE) Annual Conference & Exposition*. 16 pp. DOI 10.18260/1-2—35485. https://peer.asee.org/35485
[9] A.R. Bielefeldt, J.W. Lewis, M. Polmear, D. Knight, N. Canney, C. Swan. 2020. “Educating civil engineering students about ethics and societal impacts via co-curricular activities,” *Journal of Civil Engineering Education*, vol. 146 (4), DOI 10.1061/(ASCE)EI.2643-9115.0000021.
[10] C. Conley, S. Hamilton, and D. Hains. 2006. “ASCE student chapters: A contributor to achieving program goals,” in *Proc. American Society for Engineering Education Annual Conf. Expo*. 13 pp. DOI 10.18260/1-2—1179.
[11] A.C. Estes, E. M. Lachance, and M. D. Evans. 2003. “The role of student chapters in improving CE programs,” in *Proc. American Society for Engineering Education Annual Conf. Expo*, 11 pp. DOI 10.18260/1-2—12387.
[12] M.J. Hanson. 2015. “Introducing ethics to chemistry students in a “Research Experience for Undergraduates” (REU) Program,” *Biochemistry and Molecular Biology Education*, 76-80. DOI 10.1002/bmb.20856
[13] M.A. Holsapple, D.D. Carpenter, J.A. Sutkus, C.J. Finelli, and T.S. Harding. 2012. “Framing faculty and student discrepancies in engineering ethics education delivery,” *Journal of Engineering Education*, vol. 101 (2), pp. 169-186.
[14] J.E. Murphy. 2011. *Faculty and student perceptions of business ethics education at an undergraduate institution*. Dissertation, Capella University.
[15] A.R. Bielefeldt, N. Canney, C. Swan, D. Knight. 2016. “Contributions of learning through service to the ethics education of engineering students,” *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, vol. 11 (2), pp. 1-17. DOI 10.24908/IJSLE.V11I2.6392.
[16] C.J. Finelli, M.A. Holsapple, E. Ra, R.M. Bielby, B.A. Burt, D.D. Carpenter, T.S. Harding, J.A. Sutkus. 2012. “An assessment of engineering students’ curricular and co-curricular experiences and their ethical development,” *Journal of Engineering Education*, vol. 101 (3), pp. 469-494.
[17] B.A. Burt, D.D. Carpenter, C.J. Finelli, T.S. Harding, J. Sutkus, M. Holsapple, R.M. Bielby, and E. Ra. 2011. “Outcomes of engaging engineering undergraduates in co-curricular experiences,” in *Proc. American Society for Engineering Education Annual Conf. Expo,* 11 pp. DOI 10.18260/1-2—18498.
[18] J. Rest and D. Narvaez. 1991. “Chapter 9 – The College Experience and Moral Development,” in *Handbook of Moral Behavior and Development*, Vol. 2: Research. Ed. W.M. Kurtines, J. Gewirtz, J.L. Lamb. Pp. 229 – 245.
[19] I. Nair and W.M. Bulleit. 2018. “Framing engineering ethics education with pragmatism and care: A proposal,” in *Proc. American Society for Engineering Education Annual Conf. Expo*, 20 pp, DOI 10.18260/1-2—30537, https://peer.asee.org/30537.

[20] American Society of Civil Engineers (ASCE). 2019. *Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer. Third Edition*. ASCE, Reston VA.
[21] B.E. Barry and J.R. Herkert. 2014. "Chapter 33: Engineering Ethics," in *Cambridge Handbook of Engineering Education Research*. Ed. A. Johri and B.M. Olds, Cambridge University Press. pp. 673-692.
[22] J.C. Weidman. 2006. "Socialization of students in higher education: Organizational perspectives," in *The SAGE Handbook for Research in Education: Engaging ideas and enriching inquiry* (pp. 253–262). Sage, Beverley Hills.
[23] G. Rulifson and A.R. Bielefeldt. 2019. "Evolution of students' varied conceptualization about socially responsible engineering: A four year longitudinal study," *Sci Eg Ethics*, vol. 25, pp. 939-974. https://doi.org/10.1007/s11948-018-0042-4.
[24] N. Canney and A. Bielefeldt. 2015. "A framework for the development of social responsibility in engineers," *International Journal of Engineering Education*, vol. 31(1), pp. 414–424.
[25] A.R. Bielefeldt, M. Polmear, D. Knight, N. Canney, and C. Swan. 2019. "Disciplinary variations in ethics and societal impact topics taught in courses for engineering students," *ASCE Journal of Professional Issues in Engineering Education and Practice*, vol. 145 (4). DOI 10.1061/(ASCE)EI.1943-5541.0000415.
[26] J. Goldie, L. Schwartz, A. McConnachie, and J. Morrison. 2002. "The impact of three years' ethics teaching, in an integrated medical curriculum, on students' proposed behaviour on meeting ethical dilemmas," *Medical Education*, vol. 36, pp. 489-497.
[27] K. Paterson, C. Swan, and D.W. Watkins. 2016. "Going is not knowing: Challenges in creating intercultural engineers," in *Proc. American Society for Engineering Education Annual Conf. Expo,* 18 pp, DOI 10.18260/p.25408.
[28] K.R. Bartkus, B. Nemelka, M. Nemelka, and P. Gardner. 2012. "Clarifying the meaning of extracurricular activity: A literature review of definitions," *American Journal of Business Education*, vol. 5 (6), pp. 693-704.
[29] D.R. Simmons, J. Van Mullekom, and M.W. Ohland. 2018. "The popularity and intensity of engineering undergraduate out-of-class activities," *Journal of Engineering Education*, vol. 107 (4), pp. 611-635. DOI 10.1002/jee.20235.
[30] D. Wilson, D. Jones, MJ Kin, C. Allendoerfer, R. Bates, J. Crawford, T. Floyd-Smith, M. Plett, and N. Veilleux. 2014. "The link between cocurricular activities and academic engagement in engineering education," *Journal of Engineering Education*, vo. 103 (4), pp. 625-651. DOI 10.1002/jee.20057.
[31] D.R. Fisher, A. Bagiati, S. Sarma. 2017. "Developing professional skills in undergraduate engineering students through cocurricular involvement," *Journal of Student Affairs Research and Practice*, vol. 54 (3), pp. 286-302. DOI 10.1080/19496591.2017.1289097.
[32] P.C. Wankat, F.S. Oreovicz, and W.N. Delgass. 2000. "Integrating soft criteria into the ChE curriculum," in *Proc. American Society for Engineering Education Annual Conf. Expo*. 7 pp. DOI 10.18260/1-2—8476.
[33] P.Y. Blyden. 2009. *The effects of participation in college curricular and cocurricular programs on engineering alumni professional leadership practices*. Dissertation. University of Dayton, School of Education.
[34] T. Kinoshita, G. Young, and D.B. Knight. 2014. "Learning after learning: Perceptions of engineering alumni on skill development," *IEEE Xplore*. 978-1-4799-3922-0/14.
[35] E.L. Deci, R.J. Vallerand, L. G. Pelletier, and R.M. Ryan. 1991. "Motivation and education: The self-determination perspective," *Educ. Psychol*., vol. 26(3, 4), pp. 325–346.
[36] R.M. Ryan and E.L. Deci, 2000. "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," *Am. Psychol*., vol. 55(1), pp. 68–78.
[37] T. Garcia and P.R. Pintrich. 1996. "The effects of autonomy on motivation and performance in the college classroom," *Contemp. Educ. Psychol*., vol. 21(4), pp. 477–486.

[38] A. Mumford. 1994. “Four approaches to learning from experience,” *The Learning Organization*, vol. 1 (1), pp. 4-10. https://doi.org/10.1108/09696479410053386.
[39] A.R. Artino, J.S. LaRochelle, K.J Dezee, and H. Gehlbach. 2014. “Developing questionnaires for educational research: AMEE Guide No. 87,” *Medical Teacher*, vol. 36, pp. 463-474. DOI 10.3109/0142159X.2014.889814.
[40] A.R. Bielefeldt, M. Polmear, D. Knight, N. Canney, C. Swan. 2018. “Effective ethics education: Examining differing faculty perspectives,” *Proc. American Society for Engineering Education (ASEE) Annual Conference & Exposition*. 20 pp. DOI 10.18260/1-2--30355. https://peer.asee.org/30355.
[41] Indiana University Center for Postsecondary Research. n.d. *The Carnegie Classification of Institutions of Higher Education, 2018 edition*. Available at: https://carnegieclassifications.iu.edu/ Accessed Jan. 4, 2021.
[42] A.F. Cabrera, D.J. Weerts, and B.J. Zulick. 2005. “Making an impact with alumni surveys,” *New Directions for Institutional Research*, vol. 126, pp. 5-17. https://doi.org/10.1002/ir.144.
[43] N. Koenig-Lewis, Y. Asaad, A. Palmer, and E. Petersone. 2016. “The effects of passage of time on alumni recall of ‘student experience’,” *Higher Education Quarterly*, vol. 70 (1), pp. 59-80. DOI 10.1111/hequ.12063.
[44] American Educational Research Association, American Psychological Association, & National Council on Measurement in Education (AERA, APA, & NCME). 2014. *Standards for educational and psychological testing*. Washington, DC: American Educational Research Association.
[45] A.R. Bielefeldt, M. Polmear, D. Knight, C. Swan, N. Canney. 2018. “Intersections between engineering ethics and diversity issues in engineering education,” *Journal of Professional Issues in Engineering Education and Practice*, vol. 144 (2). DOI 10.1061/(ASCE)EI.1943-5541.0000360.
[46] National Society of Professional Engineers. 2019. *NSPE Code of Ethics for Engineers*. Available at: https://www.nspe.org/resources/ethics/code-ethics Accessed Jan. 4, 2021.
[47] D.A. Kolb. 2015. *Experiential Learning: Experience as the Source of Learning and Development*. Pearson Education, Inc. Upper Saddle River NJ.