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Creating Faculty Buy-in for Ethics-across-the-curriculum: Year One of Developing an Ethics Curriculum in an Undergraduate Biological Engineering Program

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Abstract

This paper reports the first two phases of an on-going, multi-year project that seeks to create an integrated ethics curriculum for undergraduate Biological Engineering (BE) majors at a large, public university. Our objective is to create an exemplar process that encourages engineering faculty members to contribute to, and develop ownership of, the ethics curriculum.

Literature in engineering education research has called attention to faculty buy-in as one of the key indicators of successful educational innovation. Scholars of ethics education also note engineering faculty's attitude as a crucial factor in meaningful integration of ethics in the engineering curriculum. Informed by the findings of engineering education and engineering ethics literature, our project team engages the BE faculty in an ethics curriculum development initiative with five phases: 1) need assessment interviews, 2) faculty workshops, 3) curriculum design, 4) curriculum implementation, and 5) project assessment and improvement. This paper reports in detail the first two phases of this on-going project. First, one of the authors conducted semi-structured interviews with instructors of BE courses to understand their present approaches to ethics education and the perceived need for improvement. Second, authors of this paper organized three interactive workshops, in which the BE faculty and our project team explored frameworks of ethical reasoning, pedagogy for ethics education, and ethics-related learning objectives. These engagement activities resulted in a list of 11 ethics related learning objectives agreed upon by the BE faculty; these learning objectives formed the basis of an ethics-across-the-curriculum experience for BE students.

Informed by the interview findings and the list of ethics learning objectives, the authors continue to work with a team of BE instructors to develop appropriate course contents, instructional materials, and delivery methods in four successive courses that spread across the junior and senior years of the BE curriculum. The design, implementation, and assessment of the ethics curriculum will be reported in future publications.

Introduction

In this paper, we report the first two phases of an on-going, multi-year project that seeks to create an integrated ethics curriculum for undergraduate Biological Engineering (BE) majors at a large, public university (LPU hereafter). Drawing from literature in ethics education and engineering education research, two principles guide our approach to this project. First, we aim to create a comprehensive, progressive ethics learning experience following an ethics-across-the-curriculum model [1]. Second, recognizing the pivotal role of faculty buy-in in effective educational and curricular innovation, we pursue this project as a means to explore processes for curriculum change that fully engages relevant

faculty members [2]. In so doing, we seek to create a model for ethics curriculum development that can be adapted by other engineering departments.

This paper begins with an overview of the entire curriculum development project, which consists of five phases. We then discuss in more detail the first two phases of the project: user need assessment and faculty workshops. Between the reporting of phases I and II, we also recount the project team's participation of a National Academy of Engineering (NAE) workshop, which had a significant impact on the direction of our project. We conclude this paper with lessons we learned so far and our recommendations for future research.

Project overview

At LPU, undergraduate students declare majors during their junior year. Therefore, the BE curriculum consists of junior and senior level courses. The BE major at LPU offers three options: agricultural engineering, food and biological process engineering, and natural resource engineering. According to the major requirements, students in all three options take at least nine courses in common. These common courses, spreading from semester five to semester eight, cover topics like mathematical modeling, heat and mass transfer, food and biological materials, agricultural control systems, biochemistry and microbiology, communication and leadership, and engineering design. In response to a recent ABET evaluation that took place in 2015, the BE program restructured its curriculum, adding a mandatory, two-semester capstone design experience for all undergraduate BE majors. The curriculum restructuring brought opportunities to review and improve ethics education in the BE curriculum.

According to our needs assessment (reported later), several BE instructors currently include course contents on ethical issues related to biological engineering (e.g., genetically modified organisms) or to the engineering profession. However, there was a widely shared perception among the faculty that ethics instruction across different BE courses needs better coordination, and students will benefit from a progressive ethics learning experience. Some BE faculty members also expressed a wish to better align the contents and pedagogy of ethics education in the program with ethical and educational theories. In 2016, the BE program received an internal grant from LPU's engineering education center to systematically integrate ethics into its undergraduate curriculum. This project was led by a team of four members: a BE faculty member, an ethicist, an engineering education researcher, and a postdoc in engineering ethics.

The project is expected to take three years and to unfold in five consecutive but overlapping phases. Phase I (Fall 2016) assesses BE faculty's current coverage of ethics and perceived needs for improvement. Phase II (Fall 2016-Spring 2017) engages BE faculty in the curriculum development via a series of workshops. In Phase III (Summer 2017-Spring 2018), the project team work with a subset of BE faculty members to design an ethics curriculum that spreads across junior- and senior- year BE courses. The new curriculum will be implemented in Phase IV (Beginning Fall 2018). In Phase V (Beginning Fall 2018), the project team will work with instructors of BE courses to assess its impact on students' ethics learning.

This paper focuses on year one and the first two phases of this ongoing project. Phases III to V will be reported in future publications.

Phase I: User need assessment

The project team approaches the curriculum development following a user-oriented method, in which we identify the BE faculty members as "users" of our educational innovation [3]. In order to better understand user needs, we began the project by conducting interviews with BE faculty members about their current approaches to ethics instruction, perceived challenges, and needs for improvement. With IRB approval, the first author of this paper contacted ten faculty members who taught undergraduate BE courses (one of them was located outside the department that owns the BE curriculum). Nine faculty members participated in the interviews. The semi-structured interviews lasted from 25 to 85 minutes, with most interviews ranging between 30 to 60 minutes. A sample interview protocol is included in Table 1.

Table 1-Sample Protocol for User Interview

Protocol for Interviewing Engineering Educators about Ethics Education in Undergraduate Biological Engineering Program
I am conducting these interviews as part of a study to determine how undergraduate students in the Biological Engineering program are learning about engineering ethics. The study will help me and the rest of the project team to identify areas in which we can assist your department in enhancing ethics education of its students.
1) We have learned that you have incorporated ethics topics in your undergraduate courses for BE students, would you please describe the course components in which you engage students in ethics learning? (Possible follow-up questions: In what courses do you discuss ethics? How much class time do you spend on ethics topics?)
2) What objectives do you seek to achieve when you teach ethics in the undergraduate BE courses? Would you please describe the instructional methods and materials you use for educating students about ethics? (Possible follow-up questions: How did you develop the methods and the materials that you use?)
3) Would you please describe any assignments you give students related to ethics? How do you assess students' ethics learning?
4) Are there parts of your approach to ethics education that are going well and that you would recommend to other faculty members teaching ethics to engineering undergraduates?
5) Please describe any challenges and limitations that you have encountered with your current approach to ethics education. Do you find some objectives of ethics education harder to achieve than others? Do you feel that you are able to spend sufficient class time on ethics to achieve your learning objectives? Please elaborate.
6) What types of improvements would you like to see in ethics education for undergraduates in the BE program? Are there other courses in your curriculum in which ethics could be included?
7) We are interested to learn about the types of ethical issues that you feel undergraduate students in Biological Engineering should be able to address. Could you please share your thoughts on this? Specific examples would be very helpful.
8) I have only one more topic for the interview. We would like to hear any suggestions you have on how the Leonhard Center and the Rock Ethics Institute can be helpful to the ethics education efforts in your program. (Follow-up: are there specific resources that you would suggest that we provide for ethics education in undergraduate programs?) Would you be willing to collaborate with other BE faculty and our project team to enhance ethics education in the BE program?

Eight interviewees gave consent for audio recording of the conversation. One interviewee did not consent for audio recording but permitted the interviewer to take

notes with pen and paper. The interviewer transcribed the audio records and written notes. In compliance with the IRB proposal and the informed consent letters, interview results were communicated to the project team in aggregated forms, and the speakers' identities were not revealed. Because the purpose of the interviews was information gathering instead of interpretive analysis, interviewees' responses were organized by interview questions with no further coding.

The interview results are presented in Table 2 and Table 3. Table 2 summarizes current coverage of ethics in BE courses. As the table shows, current coverage of ethics is not consistent across different BE courses. Some courses have multiple sections dedicated to ethics with clearly defined learning objectives and corresponding assignments, whereas others only include ethics on brief, sporadic occasions. Table 2 also shows that several BE instructors perceived a tension between teaching ethics and teaching technical content. In fact, this tension has led some course instructors to scale back or eliminate ethics related contents in their courses.

Table 2-Coverage of Ethics in the Current BE Curriculum

Courses	Ethics Teaching	Assignments	Objectives	Strengths	Challenges
Course 1	***Used to*** have 2 lectures to watch and discuss ethics related videos. ***Removed*** due to time pressure.	Students write about and orally present an ethical analysis.		Case studies allow for conversations.	Tension between covering ethics and technical contents.
Course 2	3 brief discussions of ethics cases (from NSPE).		Ethical awareness in personal and professional lives.	Students are engaged.	The instructor has no formal training in ethics instruction.
Course 3	Instructor reminds students of IP issues and professional ethics.				
Course 4	15~20 min presentation on different ethical stances about genetic engineering.	Search literature about one application of genetic engineering, state and defend one's ethical stances toward it.	Ethical awareness. Not accepting everything blindly.		Some students have had no ethics training. Tension between covering ethics and technical contents.
Course 5	1) Student presentation on a national issue with ethical components; 2) Students present as company recruiters; 3) ethics discussion about writing resume and job interviews.	Two presentations.	Identify the ethical dimension of a national issue. Analyze a corporation's ethical standpoint. Ethically representing oneself on the job market.	Opens students' minds. Students are analytical in ethical reasoning.	These courses are taken by different majors, who have different perspectives and expectations about the role of ethics in their careers.
Course 6	1) Case analysis of sweatshops; 2) Student choose and analyze a case related to corporate ethics; 3) A semester-long project on a Fortune 1000 company and LPU's performance on corporate social responsibility and sustainability. 4) In-class ethics debate on an ethical	Two case analyses and a final report.			

	dilemma.				
Course 7	Two 50-min lectures on ethics, covering ethical theory and issues in engineering.	Students in their final report will identify an ethical issue related to their project and use a step-based framework to analyze it.	To explore: ethics concepts, causes for ethical behavior, processes for ethical analysis and its application in cases. Prepare students for ethical analysis in project and final report.	Provides a process for approaching ethical problems.	Complexity of ethical problems. Explaining and practicing the process of ethical reasoning takes time.
Course 8	75 min class period. Watch and discuss a video on a biological engineering related lawsuit.	Analyze the credibility of views about biological engineering in media coverage.	Help students evaluate the presentation of viewpoints (from scientific and ethical standpoints).	Video engages students.	Tension between covering ethics and technical contents.

Table 3 summarizes interviewees' views on 1) potential improvement of ethics education, 2) ethical questions BE graduates should be able to address, and 3) needs for resources and support. Notably, a number of interviewees stressed the need for a program-level overhaul of current ethics instruction. Several interviewees also called for better coordination of ethics education among different BE courses. Informed by these needs, our project team helped the BE faculty develop a list of program-level ethics learning objectives in Phase II. We also facilitated the learning objectives discussion by drafting a list of potential objectives, which were partly based on the ethical questions our interviewees considered important. Meanwhile, several interviewees advised the project team to avoid building an integrated ethics curriculum from scratch. This recommendation rests on the assumption that there are existing model curricula and best practices for the BE program to adopt. However, our research of literature, as well as our participation in an NAE workshop (reported in the following section), did not support this assumption.

Table 3-Faculty perception of needs, issues, and improvement

Suggested Improvement for Ethics Education in the BE Curriculum	**Ethical Questions BE Graduates Should Be Able to Address**	**Resource Needs**
Offering a dedicated ethics course instead of covering ethics in multiple technical courses. Overhaul current coverage of ethics as well as technical contents in the BE curriculum. An organized path for ethical education in which learning in different courses can build on one another. The introduction to ethics foundations should be one of the junior classes in the fall semester that all students have to take. Ethics should be included in all three specialization options. There are more opportunities for ethics teaching in the upper level (senior year)	Intellectual Property Communicate to the public Counter unbalanced media coverage Public safety Conflict of interest Contract related issues Design of systems that meet specifications Meet quality assurance criteria and regulations Global ethics The difference between ethical design and what is accepted by regulations Ethics in the job market	A 1-credit online module on ethics. Prepare students to give expert testimony in court. Summer faculty workshops on ethics education. Effective methods for incorporating ethics from literature and other exemplar programs Teaching resources and best way to present ethics materials. Ethics related videos or teaching modules. Perhaps the curriculum development team should take a serious look at what's out there and can be used instead of recreating everything.

courses where students do design. To make sure what is taught in different classes is not repetitive but linked together. It would be hard to add a 1-credit ethics course in the junior year. Faculty members in the department need to define common expectations for students' ethics learning so they are on the same page. Offer a 1-credit ethics course to all students in the College of Engineering taught by faculty members from the Philosophy Department. Invite someone who has a professional background in ethics to guest lecture in one or two BE classes to lay the foundation during the first few weeks of a junior course.	Assess decisions between ethical considerations and cost Conduct oneself as ethical and trustworthy professionals Assess corporate ethics Corporate/organizational protocols and processes for addressing ethical challenges Educate coworkers and foster a culture of ethical behavior Engineering implementations that impact natural resources, such as pollution and fracking Knowledge and process for addressing ethical questions The impact of engineering design on human, environment and other living species	Communicate fundamental ethics concepts in accessible and "philosophy-light" manners to engineering faculty and students. More up-to-date ethics case studies, including cases that are derived from the first hand experiences of engineering alumni. Brownbag lunch presentations on ethics education. Communicate to all the faculty members about what (resource) is available and what can be done. Continued support after the period of this curriculum development project. Support for curricular changes in the College of Engineering by the Ethics Institute. An Ethics App that students can check from their phones, so that they can read the ethical reasoning process when they need.

Lessons from the NAE workshop

Shortly after this project started, members of the project team received a call for application to a workshop on "Overcoming Challenges to Infusing Ethics into the Development of Engineers," organized by the NAE's Center for Engineering, Ethics & Society. Three members of our project team applied and were accepted into the NAE workshop as a team. The fourth member of our project team was invited to the workshop as a panel speaker.

The workshop took place in the National Academy of Science Building in Washington DC from January 10 to 12, 2017. Among some 40 applications, the workshop organizers accepted 16 teams from 15 universities, which represented "current and emerging leaders in ethics and engineering" [4]. The two-day event featured three panels, nine affinity group discussions, and a poster exhibition in which every participating team presented an ongoing project of ethics education. Our poster introduced the ethics curriculum development for BE majors at LPU.

Among the many lessons we learned at the NAE workshop, two were particularly informative for our project. First, after studying each participating team's poster, we discovered that several teams at different institutions were pursuing similar projects, which aim at developing ethics curriculum for engineering programs. Conversations with these teams confirmed that there are very few, if any, well-established examples that integrate ethics across an engineering curriculum. Second, we discussed our project with a panel speaker who had abundant experience in designing and implementing curricular changes in different programs and institutions. After hearing about our project, this panel speaker reminded us that successful curricular change could not be simply copied; instead, it necessitates a process that fully engages the faculty who would eventually teach the curriculum. Contrary to the assumption expressed by some BE faculty members during

the user need interview, what we learned at the workshop confirmed the project team's view that there is no readily available, one-size-fits-all recipe for creating an ethics curriculum in the BE program. Thus we came away from the NAE workshop more determined to focus on creating a process that consistently engages the BE faculty throughout the project.

Phase II: Faculty workshops

According to the objectives of this project and what we learned from the NAE workshop, our project team took steps to ensure the curriculum design follows an interactive and inclusive process that consistently engages the BE faculty members. As of this writing, we have organized three workshops in which the project team reported the status of the project and its provisional findings to the BE faculty. The workshops also allowed the BE faculty to provide input, which was integrated in the following stages of the project.

Workshop one: demonstrating ethics instruction

The project team organized the first faculty engagement workshop while we collected data for the user needs assessment. The first workshop enabled us to discuss the objectives and scope of this project with the BE faculty. We also took advantage of the workshop to demonstrate commonly used frameworks for teaching ethical analysis in engineering.

Twelve BE faculty members attended the first workshop, which took place from noon to 2pm (lunch was provided). Two members from the project team presented basic concepts and frameworks in ethical theory and a step-based method for analyzing ethical case studies [3]. Following the presentation, the project team led the participants to discuss and analyze a case study using the step-based method. The case examines the impacts of the North American Free Trade Agreement (NAFTA) and genetically engineered corn on small farmers in Mexico. Case-based discussion allowed participating BE faculty members to clarify and apply ethics concepts and frameworks as well as to ask pedagogical questions about leading such analysis in their own classes.

Several participants communicated to one of our project team members (also a BE faculty member) that the workshop helped them understand experientially the kind of ethics learning this project aims to create.

Workshop two: negotiating ethics learning objectives

Research in learning theory suggests that goal setting is an essential factor for effective teaching and assessment [5]. Our user needs assessment and the NAE workshop also testify to the importance for the BE faculty to reach consensus on a set of ethics learning objectives. Hence, our second workshop focused on helping the BE faculty develop a list of program level ethics learning objectives.

In preparation for this workshop, the project team drafted 19 sample learning objectives. The sample list was based on ethics-related learning objectives in existing BE courses as well as faculty's perceptions of most relevant ethical issues in BE (Table 2 and Table 3). We then shared these sample learning objectives with the BE faculty in a

questionnaire (Table 4) and asked them to choose or add objectives they consider important for BE graduates.

Table 4- Possible Learning Objectives for the BE Ethics Curriculum

The list of statements contains objectives that were expressed during the interviews with BE faculty members and additional objectives were added by project leaders. Please place an "x" in the space next to those objectives that you think should be included in the program's list of ethics learning objectives.

If you do not see an objective on this list that you feel is important, please add it.

Include	No.	Learning Objectives
	1	Define ethics and engineering ethics.
	2	Give examples of ethical values.
	3	Interpret key elements of engineering codes of ethics, such as "conflict of interest."
	4	Summarize basic ethical frameworks according to major ethical theories.
	5	Understand the psychological basis of ethical/unethical behavior.
	6	Explain why it is important for Biological Engineers to act ethically.
	7	Act according to ethical principles in a professional context.
	8	Give examples of ethical issues related to Biological Engineering and explain why the issues are ethical issues.
	9	Articulate ethical responsibilities when working in a team.
	10	Identify ethical issues in current national issues or when presented with a case study.
	11	Analyze an argument in order to identify point of views and potential biases.
	12	Analyze the professional and broad societal context for ethical decisions.
	13	Evaluate the ethical responsibilities of corporations.
	14	Evaluate the ethical implications of capstone project.
	15	Apply systematic method to analyze ethical issues and to arrive at a recommended approach to address the issues.
	16	Demonstrate ethical responsibility that goes beyond compliance to professional codes and regulations.
	17	Act ethically as an engineering professional.
	18	Provide ethical leadership within a team.
	19	Provide ethical leadership within an organization.

Ten BE faculty members (including a member of our project team) participated in the second workshop. Another eight BE faculty members, who could not attend in person, returned the questionnaire by email. One additional learning objective was suggested in the emails, "Give legal implications for acting unethically (e.g., potential fines for individual or company, possible jail time depending on severity)."

Two members of our project team facilitated the second workshop. We began by dividing the participants in two groups and asking each group to deliberate and reach in-group consensus on preferred learning objectives. The two groups then convened to discuss the results. One additional learning objective, "include cultural consideration in ethical analysis," was suggested during the deliberation. After discussion between the two working groups, the participants cast their votes on objectives from the updated sample list (including two additional objectives suggested by BE faculty). The results are shown in Table 5. The collective discussion led to a few changes to the list of potential

objectives. First, objective 7 was rephrased as "***Explain how to*** act according to ethical principles in a professional context." The participants felt that graduates' actions in the professional context is hard to discern in college classrooms, whereas their ability to explain ethical actions can be more effectively assessed. Second, we removed objectives 17 and 19 for repetition with other objectives. After counting the votes, the participants discussed the inclusion criterion and agreed that those receiving at least ten votes should be included as the program objectives. An exception was made for the recently proposed objective 21. While faculty members who were not present could not have cast their vote on this objective, it received nine votes out of the ten participating faculty, indicating a high degree of faculty preference. The participants thus decided to include objective 21 in the program list. The final list of ethics learning objectives for the BE program are as follows:

1. Define ethics and engineering ethics.
2. Give examples of ethical values.
3. Interpret key elements of engineering codes of ethics, such as "conflict of interest."
4. Explain why it is important for Biological Engineers to act ethically.
5. Act according to ethical principles in a professional context.
6. Give examples of ethical issues related to Biological Engineering and explain why the issues are ethical issues.
7. Articulate ethical responsibilities when working in a team.
8. Analyze the professional and broad societal context for ethical decisions.
9. Evaluate the ethical implications of capstone project.
10. Provide ethical leadership within a team.
11. Include cultural considerations in ethical analysis.

Table 5-BE Faculty Votes on Ethics Learning Objectives

Votes	No.	Learning Objectives
18	1	Define ethics and engineering ethics.
16	2	Give examples of ethical values.
14	3	Interpret key elements of engineering codes of ethics, such as "conflict of interest."
9	4	Summarize basic ethical frameworks according to major ethical theories.
7	5	Understand the psychological basis of ethical/unethical behavior.
12	6	Explain why it is important for Biological Engineers to act ethically.
10	7	**Explain how to** act according to ethical principles in a professional context.
16	8	Give examples of ethical issues related to Biological Engineering and explain why the issues are ethical issues.
14	9	Articulate ethical responsibilities when working in a team.
9	10	Identify ethical issues in current national issues or when presented with a case study.
9	11	Analyze an argument in order to identify point of views and potential biases.
10	12	Analyze the professional and broad societal context for ethical decisions.
8	13	Evaluate the ethical responsibilities of corporations.
13	14	Evaluate the ethical implications of capstone project.
9	15	Apply systematic method to analyze ethical issues and to arrive at a recommended approach to address the issues.
7	16	Demonstrate ethical responsibility that goes beyond compliance to professional codes and regulations.
	17	~~Act ethically as an engineering professional.~~
11	18	Provide ethical leadership within a team.
	19	~~Provide ethical leadership within an organization.~~
4/10	20	Give legal implications for acting unethically (eg, potential fines for individual or company, possible jail time depending on severity).

9/10	21	Include cultural considerations in ethical analysis.

Workshop three: building consensus for moving forward

Having developed a list of program level ethics learning objectives, the project team then worked toward connecting these learning objectives with specific course materials and pedagogical practice. We started this process by translating each learning objective into relevant knowledge, skills, and abilities (KSA). The KSA framework provides a visual tool for us to connect learning objectives with concrete activities of teaching, learning, and assessment. During our third workshop, one project team member (Director of the Engineering Education Center) presented the KSA framework and exemplar teaching activities (Table 6) to BE faculty members. The ethicist in our project team (Associate Director of the Rock Ethics Institute) also introduced three frameworks (virtue ethics, deontology, and consequentialism) that are fundamental for students to develop relevant KSA in meeting the learning objectives. Significant time of the third workshop was reserved for BE faculty members to discuss, ask questions, and build consensus on plans for the upcoming curriculum development, implementation, and assessment.

Table 6-The KSA Model of BE Ethics Learning Objectives

	Knowledge, skills, and abilities (KSA)	**Associated Learning Objectives**	**Teaching, Learning, and Assessment**
Knowledge	• Definition of ethics, engineering ethics • Ethical values and principles • Codes of Ethics • Ethical frameworks • Types of Justice • Definition of culture • Variation of ethical values/principles across cultures	1. Define ethics and engineering ethics. 2. Give examples of ethical values. 3. Interpret key elements of engineering codes of ethics, such as "conflict of interest."	• Teaching: o Lecture/online instruction on ethics, engineering ethics, values, principles, frameworks, etc. • Assignments: • Assessment:
Skills and Abilities	• Identify ethical issues (Ethics spotting) • Moral imagination • Ethics problem solving process • Identify potential cultural influences in ethical problem solving	4. Give examples of ethical issues related to Biological Engineering and explain why the issues are ethical issues.	• Teaching o Lecture/online instruction ethics spotting, moral imagination, ethics problem solving process o Work through examples in class to practice ethics spotting o Create ethical network map in class to build moral imagination • Assignments: • Assessment:
Application of KSA	• Explain ethical issues in BE • Relate ethical values/principles to codes of ethics • Identify cultural influences in ethical "problems" related to BE • Develop and defend recommended actions in simple cases (dilemmas) • Develop and defend recommendation actions in complex cases	5. Explain why it is important for Biological Engineers to act ethically. 6. Explain how to act according to ethical principles in a professional context. 7. Articulate ethical responsibilities when working in a team. 8. Provide ethical leadership within a team.	• Teaching: o Capstone lectures that include exemplar analysis of a complex ethical case study • Assignments: o In-depth, unscaffolded ethical analysis in capstone project report. (Ideally, each student would do an individual analysis that would be graded, then these would be combined

		9. Analyze the professional and broad societal context for ethical decisions. 10. Evaluate the ethical implications of capstone project. 11. Include cultural considerations in ethical analysis	into final report.) Assessment:

The third workshop led to a number of agreements: 1. A small number of BE faculty members would form a curriculum development team. Beginning in the summer of 2017, this team would identify existing course components or create new materials for teaching ethics across the BE curriculum. 2. Instructors of BE courses would work with the curriculum team to implement newly developed materials and pedagogical models. 3. The BE program decided to submit a second grant proposal to the Engineering Education Center for supporting the implementation and assessment of the new curriculum. Figure 1 illustrates the plan of work agreed by participants at the third faculty workshop.

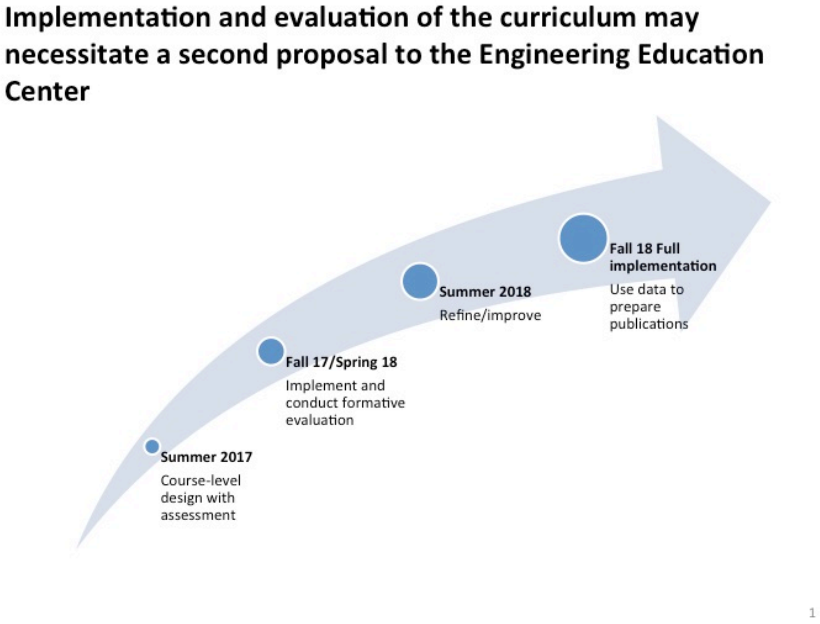

Figure 1-Plan for Phases III to V

Conclusion

This paper reports the first two phases of an on-going project that seeks to integrate ethics into an undergraduate BE curriculum. In particular, the paper focuses on the process and strategies we have utilized in order to engage our users, the BE faculty members, into the curriculum development. This project began (in Phase I) with a study of current ethics instruction in the curriculum and faculty's perceived challenges and needs. Throughout the project, we maintained timely and consistent communication with the BE faculty via regular workshops. Through these measures, we received faculty consensus on a list of

program level ethics learning objectives as well as a plan for curriculum development, implementation, and assessment.

Our project experience so far has generated several lessons on effective curriculum changes for engineering ethics education. First, to reiterate a point we have stated above, we recommend a bottom-up approach to curriculum development that fully engages faculty members in the engineering program. Our project team is committed to engaging the BE faculty, even when some faculty members do not display strong enthusiasm for participation, either because they are flexible with what the project team has to offer or because of a concern that substantial involvement of the entire faculty runs the risk of "reinventing the wheel." Second, as most members of our project team are external to the BE program, we found a need to remind the BE faculty that they are the ultimate owner of the ethics curriculum. At times we frankly shared with the BE faculty what the project team could provide (e.g., educational media, teaching materials), and what we could not do on their behalf (e.g., teaching ethics sessions in BE courses). Third, the composition of a project team with trans-disciplinary expertise in engineering, ethics, and engineering education makes us well equipped for designing an ethics curriculum for an engineering program, a task that is in itself trans-disciplinary. Lastly, we learned that having a faculty leader and strong support from the department head are critical to the initiation of the project and to keeping it on track. The value of a project leader internal to the BE faculty and the department head's support is partially demonstrated through the fact that we encountered no open resistance to this project to this date. Also, external grant support from LPU's engineering education center might have helped reduce skepticism in the BE program.

While this project consistently integrates faculty needs and inputs, we also recognize its inadequately inclusion of student perspectives. The project team made a conscious choice to prioritize faculty perspectives: compared with individual students who undergo the BE curriculum only once, faculty members display relative stability in their experience with the courses. Hence faculty members are able to provide information about their respective courses from a longitudinal viewpoint. Still, we recommend future research in ethics curriculum development to more extensively assess and integrate student perspectives and needs.

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References

[1] Mitcham, C., and Englehardt, E. E. 2016. "Ethics Across the Curriculum: Prospects for Broader (and Deeper) Teaching and Learning in Research and Engineering Ethics." *Science and Engineering Ethics*, 1-28.

[2] Litzinger, T. A., and Lattuca, L. R. 2014. “Translating Research to Widespread Practice in Engineering Education.” In A. Johri, and B. M. Olds eds. *Cambridge Handbook of Engineering Education Research*. Cambridge University Press.

[3] Tang, X., Mendieta, E., and Litzinger, T. A. 2017. “Building a Community of Ethics Educators in Graduate Engineering Programs: Developing an Ethics Workshop Following a User-Oriented Approach.” In Proceedings of American Society for Engineering Education Annual Conference.

[4] NAE (National Academy of Engineering). 2017. *Overcoming Challenges to Infusing Ethics into the Development of Engineers: Proceedings of a Workshop*. The National Academies Press, Washington, DC.

[5] Andrade, H. L. 2013. “Classroom Assessment in the Context of Learning Theory and Research.” In James, H. McMillan ed. *Sage Handbook of Research on Classroom Assessment*. Sage Publications.