

[Ethics Practice Paper] Why Communities of Practice Matter in Ethics Education - Reflections on Experiences and Lessons Learned

Dr. Alison J Kerr, Colorado School of Mines

Alison J. Kerr has a doctoral degree in Industrial-Organizational Psychology from The University of Tulsa. Dr. Kerr's research interests include training development and evaluation as explored across a variety of academic disciplines and organizational settings. She is currently the Director of Futures at the Colorado School of Mines where she gets the opportunity to introduce students to the complex systems relevant to the future of our world. She has the extra benefit of working with faculty across many different fields and disciplines to create opportunities for impact.

Dr. Andrew O. Brightman, Purdue University – West Lafayette (College of Engineering)

Andrew O. Brightman is Professor of Engineering Practice in the Weldon School of Biomedical Engineering. His research background is in cellular biochemistry, tissue engineering, engineering ethics, and diversity, equity, and inclusion in engineering education. Professor Brightman is an inaugural Fellow of the Online Ethics Center for Engineering and Science and has been developing a Community of Practice around Ethics Education in Biomedical Engineering to develop and disseminate best practices for ethics training for the field of Biomedical Engineering.

Dr. Nicholas D. Fila, Iowa State University of Science and Technology

Nicholas D. Fila is an assistant teaching professor in the Department of Electrical and Computer Engineering at Iowa State University. He earned a B.S. in Electrical Engineering and a M.S. in Electrical and Computer Engineering from the University of Illinois-Urbana-Champaign and a Ph.D. in Engineering Education from Purdue University. His research interests include empathy, ethics, design thinking, and course design.

Dr. Justin L Hess, Purdue University – West Lafayette (College of Engineering)

Dr. Justin L Hess is an assistant professor in the School of Engineering Education at Purdue University. Dr. Hess's research interests include exploring empathy's functional role in engineering and design; advancing the state of the art of engineering.

Why Communities of Practice Matter in Ethics Education: Reflections on Experiences and Lessons Learned

Abstract

This theory-to-practice paper examines the role and structure of communities of practice (CoPs) and their importance to ethics education in engineering. Communities of practice originate from Lave and Wenger's situated learning theory. They represent affinity groups who regularly interact to share ideas, deepen expertise, and explore topics of mutual interest. Here, we explore the concept and practice of a CoP focused on applied ethics research and teaching. Applied ethics is based on shared values, beliefs, and practices, thus no one individual or small group can adequately nor effectively develop new research findings into best educational practices. We unpack, through theoretical discussion and practical examples, CoPs as mechanisms for (1) building community around a specific topic of interest to deepen inquiry, (2) more effective translation of research into practice, (3) integrating broader perspectives while developing best practices, and (4) ensuring broader impact through expanded conversation, dissemination, and application in educational settings.

This paper documents the development, practice, and outcomes of a CoP formed around the topic of ethical engineering research in biomedical engineering. This CoP has operated for five years and has engaged a broad and diverse group of faculty, staff, and student members from a range of academic institutions. The primary functions of this CoP have been (1) reflecting on research findings (e.g., alignment with CoP members' experiences), (2) identifying how the research findings can inform educational strategies for ethical formation in biomedical engineering, especially in departmental and research lab contexts, and (3) translating research findings into educational practices for BME programs more broadly. This CoP also has interacted with the Education and Ethics Committees of the Biomedical Engineering Society (BMES) and the Online Ethics Center to support sharing of experiences and ideas among other practitioners with emerging or established interests in ethics education. The CoP has been developed and sustained through several activities including: interactive sessions with a research team exploring ethical engineering research among BME faculty (about twice per year), informal gatherings and discussions at the national conference of BMES (annually), and multiple other networking and dissemination activities (ad hoc). Topics of discussion and activity varied but generally focused on awareness of engineering ethics education and related programmatic needs and practices; learning objectives, approaches, assessments in engineering ethics education; and learner experiences and needs.

The CoP's activities have produced several value adding outcomes and lessons learned relevant to engineering ethics research, education, and engineering practice, which we explore through Systemization of Experiences. These activities, experiences, and findings fall into several themes for how they add valuable insight into the benefits of developing Communities of Practice around ethics. For example, the CoP has provided a communicative validation check of emergent research findings. Second, the CoP has identified how the research findings might inform educational and culture-building strategies. Third, the CoP has distributed findings to relevant communities, including professional societies (e.g., BMES, ASEE's Biomedical Engineering Division), other formal communities of practice, and members' own institutions and colleagues. Finally,

participation has supported insights, motivations, and opportunities for individual CoP members research and teaching of ethics. We explore these themes and their implications for providing a foundation for advancing ethics training in BME programs as well as among other engineering disciplines.

Introduction

The NSF-funded ethics education research project associated with this CoP explored the variation in ways of experiencing ethical engineering research by faculty members in biomedical engineering (BME). While faculty members are primary stewards of culture in universities, departments, and their respective research groups, developing ethical cultures of research requires input and participation from many stakeholders. Perceptions of what constitutes ethics, how to teach it (if at all), and whose job it is to teach it, varies widely [2-4]. This variation is evident in two publications by the National Academy of Engineering (NAE). The first argues that programs must integrate ethics into the curriculum despite skeptical views among some faculty in engineering, such as the potential impact of ethics education [5]. The second identified more than two dozen exemplary programs in ethics education [6] by faculty members in and beyond engineering disciplines who are convinced of the importance of finding effective means for ethical formation, but whose aims and goals vary widely. Despite the impressive growth and innovations in STEM research training [7-9], including among these exemplary programs [6], there are still far too many examples of industry scandals and research misconduct in engineering [10]. This wide variation in the expectations and outcomes of ethics training programs in engineering remains a problem. This situation is jeopardizing the entire engineering teaching and research enterprise, as students, postdocs, and even faculty members themselves can find themselves unprepared for ethical research and practice. Therefore, we designed a research-to-practice project to (1) elucidate the perspectives of faculty members on ethical engineering research and then (2) apply these perspectives towards the development of better training materials and practices for ethics education.

Biomedical engineering (BME) is a quickly growing field of STEM research and practice. This engineering discipline is especially important to study given that it is relatively young and the ethical impacts of this field on the health and well-being of society are significant [12, 13]. Popular documentary reports of ethical challenges in health technology development such as *Bad Blood* [14], *The Bleeding Edge* [15], and *Coded Bias* [16] have raised serious concerns about ethics in BME research and practice. In light of these concerns, we began an earlier research project focused on how engineers experience ethics while working in the health products industry, an industry where many biomedical engineers are professionally employed [17-19]. The findings inspired us to initiate the current research on faculty experiences of ethics in BME research for comparison [20]. The ultimate aim is to generate understanding of how ethical phenomena manifest discretely across cultures and practices of both academic and workforce contexts.

Our ultimate goal for our funded research projects has been to support effective ethics training, particularly at the nexus of industry and academia within this discipline of engineering, with the long-term objective of synthesizing ethics in similar ways in other engineering disciplines. Importantly, we have sought to use research findings to inform educational practice in practical ways. To this end, we recognized the need for a community of practice. Communities of practice (CoPs) originate from Lave and Wenger's (1991) situated learning theory [21]. They represent affinity groups who regularly interact to share ideas, deepen expertise, and explore topics of mutual

interest. CoPs can act as mechanisms for (1) building community around a specific topic of interest to deepen inquiry, (2) more effective translation of research into practice, (3) integrating broader perspectives while developing best practices, and (4) ensuring broader impact through expanded conversation, dissemination, and application in educational settings.

In this paper, we reflect on five years of experiences with fostering a CoP on translating our research findings to educational practice. We use the qualitative methodology of Systemization of Experiences (SoE) [1] to analyze our CoP experiences and to generate lessons learned regarding cultivating ethics education, culture, and practice in engineering. The methodology of SoE supports translating learnings from practice-based experiences and projects. These types of projects can begin with a specific ‘action hypothesis’ [1] and a clear strategy for implementation. Our action hypothesis was that a community of practice (CoP) can support our engineering ethics education research. Over 5 years, we developed and cultivated a CoP to support our research in three ways: (1) to validate the findings, (2) to translate the findings into usable pedagogical tools and strategies, and (3) to disseminate results to other educators. Through SoE, we contextualize our action hypotheses and provide novel insights (lessons learned) based on our CoP experiences and observations.

Engaging a CoP Focused on Ethics in BME

Communities of practice are “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise by interacting on an ongoing basis” [22]. A key characteristic of CoPs is *legitimate peripheral participation* [21, 23], which emphasizes the importance of interacting with others who bring unique perspectives and expertise to collaboratively address authentic problems, such as considering how best to cultivate ethical cultures of BME research and education.

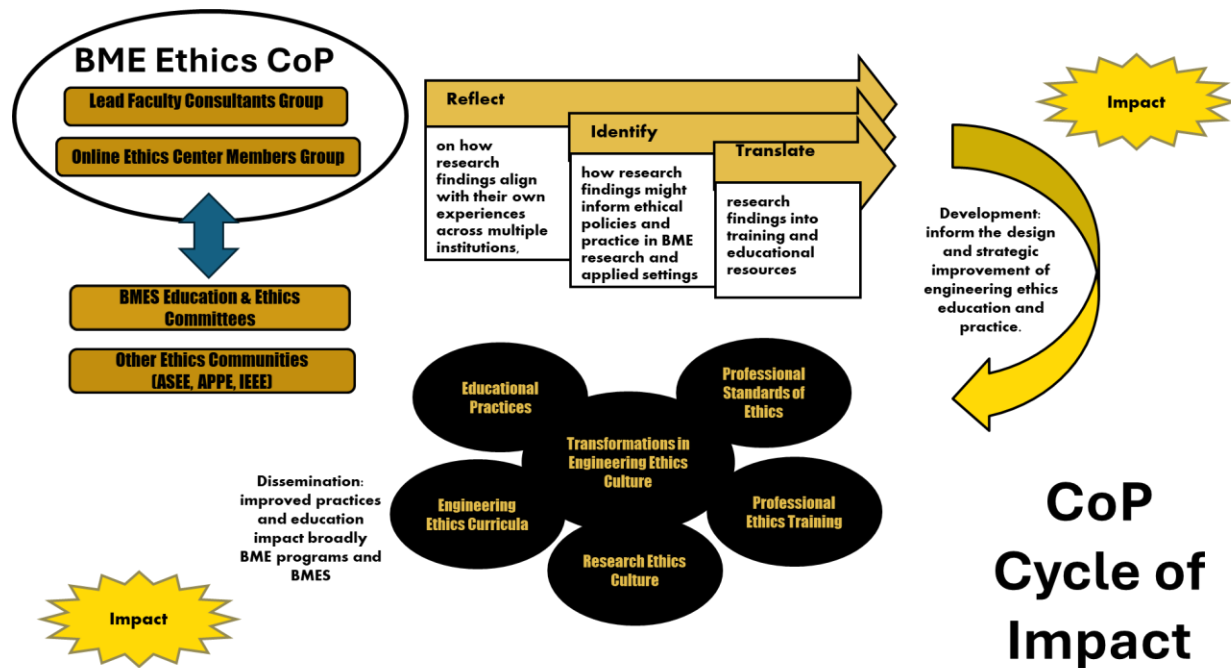
CoPs provide one key modality for improving STEM education [24]. CoPs have been reported as a strategy for enhancing educational practices in STEM generally [24], in chemistry [25], in geosciences [26], and more specifically in engineering education research [27] and professional development [28-30], and even more relevant to this project, in BME [31]. However, few CoPs have focused exclusively on ethics research, practice, or education. A CoP was developed for healthcare ethics education [32] and recently for legal ethics [33]. Also, an early form of a CoP in BME was formed in 1999 among BME faculty from several universities (i.e., the NSF-funded VaNTH ERC for Bioengineering Educational Technologies). This educational ERC focused on collecting, cataloguing, and developing enabling technologies and teaching materials for the future of bioengineering [36-35]. Yet, despite the ERC identifying ethics as a core competency in bioengineering, they placed little focus on ethics education approaches [34].

Designing the BME Ethics CoP

Previously, members our research team engaged a small community of faculty in a BME program at a single institution to develop a framework for translating ethics research to educational practice [38]. From this experience, they learned lessons about the challenges of CoP development. We were eager to engage a CoP that was open to a broader membership and focused on practical ethics education and training applications for developing ethical cultures in BME. In 2020, we developed a CoP focused on ethics in BME. Since then, we have engaged a broad and diverse population of over 50 members from the Biomedical Engineering and Engineering Education

communities. **Figure 1** provides a visual depiction of our theory of impact. We refined the model over time based on lessons learned. In this study, we will detail these evolutions, particularly pertaining to (1) CoP membership, (2) activities, and (3) impact.

Figure 1: Cycle of Impact for a Biomedical Engineering Ethics Community of Practice



BME Ethics CoP Membership

Our CoP included two sub-groups: (1) Lead Faculty Consultants or LFCs and (2) Online Ethics Center (OEC) Members. We further detail the origin and evolution of these sub-groups here. In the remainder of the paper, we describe both the OEC CoP and the LFCs as a single BME Ethics CoP and when sub-group elements are pertinent, we specify.

Lead Faculty Consultants (LFC) Subgroup

We initiated the CoP by engaging faculty members, or “LFCs”, from 12 institutions. All original LFCs have continued with the project, and at the time of this writing there are 13 active LFC members. We invited faculty to be LFC members who (1) are leaders in ethics education in biomedical engineering as evident through their participation in BMES or their scholarship and (2) bring unique perspectives, programs, and roles. The LFC members are primarily BME faculty members representing 13 different types of academic institutions across the US that served differing populations of students. While roles have changed over time, the position titles include 2 teaching faculty, 10 tenured or tenure-track faculty, and 1 emeritus professor. Additional roles and titles for these faculty include 1 department head, 2 graduate program directors, and one associate chair for research & graduate studies. All LFC members have some affiliation with Biomedical Engineering or Bioengineering programs.

LFC roles were directly associated with our NSF study and included engaging with research findings, consulting on how to apply research findings through analysis of current educational approaches for ethics training in BME, identifying gaps in BME ethics education, research, and practice, and developing evidence-based guidelines for best practices specific to BME. LFCs collectively brought or encouraged connections with professional organizations, including the Education and Ethics Committees of the Biomedical Engineering Society (BMES), Ethics and Biomedical Engineering Divisions of ASEE, and the Online Ethics Center for Science and Engineering (OEC). These connections aimed to provide support and a wider network and scale of influence, specifically for translating project findings to educational practices. In addition to engaging with professional organizations, LFCs helped share findings with faculty, staff, administrators, and students from their organizations. In addition, these participants helped us recruit others into the OEC online community of practice (i.e., the second CoP sub-group).

OEC BME Ethics CoP Subgroup

Our project proposal began with one CoP detailed as a collection of select research faculty but also formed in conjunction with the Online Ethics Center for Engineering and Science's initiative to cultivate ethics communities of practice. Our team committed to supporting the formation of one of the disciplinary CoPs specifically around BME ethics. One of our research team members became the lead fellow and another served as an advisory board member for the OEC sub-group. At the time, another member of our research team was a postdoc who also supported CoP efforts for both the LFC and the OEC subgroups.

To build OEC CoP membership, we invited prospective members who would then be part of supporting the growth of the CoP and determining activities, events, or other pursuits that would be valuable for the broader BME community, particular instructors and mentors [39]. As this is a discipline-specific CoP, prospective members included anyone who had affiliations with or interest in BME, Bioengineering, or adjacent fields. We solicited members informally through our networks and relevant professional societies.

We began by developing an email list of interested individuals, posting in society mailings and newsletters, and live recruitment at conferences and related events. In 2021 and 2022, both the OEC and our research team attended conferences like ASEE, APPE, and BMES and shared information about the forming CoP and collected emails from interested people. We also circulated flyers and postcards with scans that prompted prospective members to digital sign-up through the OEC website. Membership in the OEC sub-group has been larger in numbers and much more diverse but less consistently active when compared to the LFC subgroup. However, this group is more representative of the broader ethics education community and created opportunities for different activities than the LFC group.

Activities of the BME CoP

As reported in [17], the main activities of the CoP included: (1) ***reflection*** among a diverse group of faculty members on the applicability of research findings in their specific contexts, (2) ***identification*** of how these research findings may inform approaches to fostering ethical research cultures in CoP members' departments and research groups, and (3) ***translation*** of findings into educational approaches for fostering ethical cultures in BME research and industry practice. Here, we describe how these activities manifested by sub-group and collectively.

Activities of LFC Subgroup

The BME Ethics CoP has been further developed and sustained through several activities, including: (1) interactive virtual sessions of “LFC summits” focused on research findings, i.e. ethical engineering research among BME faculty (about twice per year), (2) strategic networking and dissemination activities through the OEC, and (3) Additional formal and informal convenings and discussions at national conferences (annually). During summits, the research team shared current research progress and intermediate findings with the LFCs. We then engaged in interactive conversations around the findings, guiding questions, and timely topics regarding translating research to practice. Example summit topics include:

- During the Fall 2024 LFC session, we shared our emerging research findings for feedback. We also engaged LFC participants in a preliminary discussion regarding how the results can inform teaching and training practices at their sites.
- During the Spring 2025 LFC session, we shared a synthesis of heuristics (research-derived education design strategies) developed from the prior session as well as the current set of heuristics based on our research findings. We engaged the LFC members in reflection on these heuristics, as well as a dialogue regarding how/where they may be positioned to situate heuristics at their sites.

Activities of OEC BME Ethics CoP Subgroup

This CoP sub-group met virtually for quarterly meetings. During meetings, discussion focused on (1) awareness of engineering ethics education and related programmatic needs and practices; (2) learning objectives, approaches, assessments in engineering ethics education; and (3) learner experiences and needs. Content topics associated with this group included:

- Responsible for teaching ethics or embedding ethics in a curriculum
- Conducting research on ethics issues and ethics pedagogy
- Developing or revising a professional code of ethics
- Providing professional development opportunities related to ethics
- Training responsible and ethical research and practice

In spring of 2025, we developed a 3-part series focused on community and conversation around BME ethics education practices. These were formatted these as virtual gatherings with members of the CoP subgroup. This series supported distribution of a crowd-sourced collection of BME ethics education and programs as well as to present and share preliminary results from the conclusion to our research project similar to what the LFC summit that year also discussed. Associated with these efforts, an undergraduate research assistant served as lead on the first part of this project to collect information on ethics education at BME programs across the country by searching available websites for information on BME related ethics classes and programs [40]. This information was collected into a spreadsheet that was then cleaned and shared as a community crowdsourcing for additional information and further details. This shared document and related topic discussions were also shared beyond the virtual meetings. As this CoP sub-group provided many additional opportunities for members to network, share resources and practices, and develop

educational materials toward preparation for professional practice at other events attended by members of the BME CoP.

Activities for Both Sub-Groups

Since 2022, we have cultivated opportunities for CoP interactions at each of the BMES annual meetings. Many members of the CoP attend this event, and we have thus aimed to meet and provide opportunities to gather the CoP in person (e.g., special sessions, workshops, coffee meet ups, meals). The BMES convenings also provide an opportune time recruitment into one or both CoP sub-groups, as it has had large student and educator attendance. Example BMES activities that we conducted include:

- ***Association for Practical and Professional Ethics (APPE)***: We presented posters and talks to share our research work with broader engineering ethics communities and to recruit additional interest and membership in the CoP. During APPE 2022, we presented a poster similar to Figure 1 with the goal of growing the CoP.
- ***American Society for Engineering Education (ASEE)***: We held special sessions at ASEE, often as part of a co-sponsored, shared division feature, including an ASEE 2022 Shared Special Session with BED and ETHICS divisions and a 2025 ASEE Special Session.
- ***Biomedical Engineering Society (BMES)***: In October 2024, we convened a special gathering at the BMES Annual Conference which included (a) coffee, (b) featuring students and student work on ethics education in BME at a table, and (c) soliciting survey responses on this work from ethics educators, BME educators, students, and other BME community members. These activities led to the creation of a Crowdsourcing Document for gathering information about current Ethics Education in BME. Also, during the annual national meeting of BMES in Oct. 2024, we continued to collect information from BME programs across the country on how and where ethics is taught in BME curricula.
- ***IEEE International Symposium on Ethics in Engineering, Science, and Technology***: In 2025, the team joined the IEEE-Ethics Conference and shared emergent findings for audience input and discussion, similar to how we engaged the LFCs at the prior summit.

Value Adding Outcomes

The impact we sought through value adding outcomes was that participants in the CoP feel prepared to apply knowledge from research findings and begin to implement practices into their immediate environments. We theorized that the CoP activities experiences would (1) familiarize CoP members with the current state of ethics education in BME research and practice which would (2) position findings in contextually sensitive ways based on the needs and variations in their diverse educational contexts. We also anticipated that the momentum and impact of the work completed by the end of the project, coupled with the overarching need for further development of effective approaches to ethical formation in BME, would be a strong incentive for continuation of this CoP through partnership with the OEC. Thus, while LFCs consulted on an NSF-funded research project and received some remuneration for their work, the second, voluntary, sub-group was designed to live beyond the grant.

The CoP's activities have produced several outcomes relevant to our original goals, including several other important outcomes. While we did not set out to extensively examine the process of the CoP formation, through reflection, discussion, and subsequent strategic planning

of next steps we have conducted a systemization of experiences to identify these outcomes as well as additional lessons learned about the ways in which the growing BME Ethics CoP has contributed to our research to practice objectives and to the larger conversations around BME Ethics. This reflective analysis of the objectives, strategies, experiences, and outcomes of the CoP we have identified four value adding outcomes.

Outcome 1: Communicative Validation

The first way in which the CoP contributed to the value of our research was in providing validation and insight into emergent research findings. Each interaction with the CoP aided in validating or driving our research forward. LFC members provided insights on all three primary research questions from our project: RQ1 addressing interviews, analysis, and development of categories of description and the phenomenographic outcome space; RQ2 addressing the categories of critical incidents from critical incident technique; and RQ3 addressing development of heuristics specific to BME ethics. In addition, LFC members reviewed and provided feedback on the various presentations of research findings in both papers and special sessions such as ASEE and BMES special sessions, and ASEE, IEEE-Ethics, and BMES presentations. Findings pertaining to this theme are reported in [20].

Outcome 2: Informing Educational and Culture-Building Strategies

The BME Ethics CoP aided in identifying how the research findings might inform educational and culture-building strategies in BME and potentially other engineering disciplines. For example, in early 2025, we created a three-part series for the OEC BME CoP around BME Ethics Education. This was timed to support final stages of the NSF research study, specifically regarding dissemination to student and instructor communities. We focused each session of the CoP meetings on (1) generating conversation and awareness of both general engineering ethics education and needs and practices within BME spaces, (2) BME and other Engineering Ethics Instruction learning objectives, approaches, assessments, and (3) Student and learner experiences and further needs.

Outcome 3: Distribution and Application of Research Findings

Third, the CoP assisted with distributing findings to relevant communities including professional societies (e.g., BMES, ASEE's Biomedical Engineering Division), other formal communities of practice, and members' own institutions and colleagues. For example, in 2023, an LFC member invited our team to present findings to the department of BME at Texas A&M University. The audience for this seminar included faculty and students in BME at the university, including an LFC member. Also in 2023, and based on LFC conversations, we developed a special BMES session entitled, "Beyond Responsible Conduct of Research to Discipline-Specific Training: Evaluating Insights from Faculty Experiences with Ethics in Biomedical Engineering Research." This interactive session introduced our research study, including topics and themes of ethical and responsible research in biomedical engineering.

While the above examples provide evidence of how the CoP helped us amplify our distribution of knowledge, the knowledge diffused within the CoP is also of note. For example, we have actively shared research data associated with phenomenography, critical incidents, and

heuristics. When we share findings, we have actively engaged participants in conversations regarding how the research can inform their instructional or mentoring practices and their research approaches. Given the senior roles of many of our participants both in their institutions and professional societies, these discussions directly lead to enhancing infrastructure for research training across a set of institutions via the identification, development, and testing of training practices in ethical engineering research.

Outcome 4: Community Conversations and Growth

Finally, CoP participation has supported insights, motivations, and opportunities for development of collective approaches to teaching ethics and conducting ethics research. While the research projects sought to engage a CoP to bolster research to practice among individual participants and labs, an additional outcome of cultivating the BME Ethics CoP is that it has served to further the visibility and engagement with ethics and ethics education practices for the larger Biomedical Engineering and Engineering Ethics conversations. Furthermore, the activity of this CoP has helped inform BME educators' strategies for cultivating ethical engineering.

Resources we have developed, such as a crowd-sourced materials on BME ethics and mentoring, have created interest and engagement with BME and other Engineering Educators. These resources have helped grow the potential BME community, positioning us to develop and test ethics education heuristics with an even more expansive population.

Through our many activities and outcomes, the CoP has also grown the capacity for BME ethics research. Specifically, students who have worked on this project or have joined these communities have begun work with additional BME research teams. One has joined a project to develop new types of vaccines and has entered into a combined Master 's degree program. Another has also pursued graduate school in the Biomedical space.

Lessons Learned

While throughout this paper, we have described membership, activities, and value adding outcomes from the CoP, here we reflect on those experiences and generate lessons learned using the methodology of Systemization of Experiences [1]. Here we identify eight lessons learned that provide a basis for developing new strategies for future efforts.

There is a need for flexibility. Throughout the project, we provided multiple options for many meetings. In our proposal, we were specific regarding how often and when the CoP would meet. However, even the first meeting of the LFC group took six months to schedule. When engaging a group of busy practitioners, it makes sense that finding a convenient time for them all to gather is difficult. Our first meeting was intended to be 3 hours long, but we parsed it down to two hours. Even then, some people had to arrive late or leave early. In subsequent years, we could not find a time to meet that worked for everyone, so we booked two 90-minute windows. Even convenings like BMES, when a majority of the BME Ethics CoP members were in attendance, proved challenging to find a time to congregate. We went from trying to have a summit at this conference, to a meal, to eventually landing on a simple coffee session for anyone who could join. The key learning here is not just that multiple times and options are good to have, it is also good to acknowledge that this is what a CoP needs to thrive so that members feel like they can be in step even if they miss a few. The convenings need to be regular, inclusive,

and include some discussion of other events with a contingency plan to make sure that those who miss can catch up (e.g., sharing recordings of sessions, emails listing key outcomes).

Leadership engagement is essential to sustaining CoP activities. Many of the LFC members were also members of the OEC subgroup as well as members and leaders in the BME and ASEE societies. Their interactions with the Education and Ethics Committees of BMES and OEC supported sharing of experiences and ideas among other practitioners with emerging or established interests in ethics education. Over the five years, additional members have joined both the LFC and the OEC subgroups, and we have sought and invited those with varying backgrounds and experiences to expand the influence of the CoP. Initially, we did not explicitly recognize our research team as members of the CoP. However, it became clear that our research team's participation and leadership was a central element of the functioning of both subgroups of the CoP. Thus, we now also consider ourselves as important leaders and members of the growing BME Ethics CoP.

Variety of activities and opportunities yields a broader and more productive CoP. As mentioned in the activities section, we originally thought we would have one CoP, and while we have organized this paper to express the large BME Ethics CoP, the discovery of the need to clarify when we were doing LFC summits, BMES conference activities, and OEC membership events is as much for the paper as it was for clarifying how we would be reaching out and welcoming different CoP members for different relevant conversations and developmental opportunities. While we did invite additional teaching faculty to the LFC groups, the OEC membership was helpful in engaging additional BME educators and current instructors. This was why the goals for 2025 OEC CoP convenings was a 3-part series on BME Ethics Education, i.e., we wanted to engage more members, insights, and support the growth of our community's understanding of the current state and needs in BME ethics education.

Engaging more diverse members of the CoP adds value. We started out with a small group of BME faculty. During the research and development of the CoP, we uncovered a desire to include more perspectives and insights, such as those from a more expansive teaching instructors, early-career faculty, and students. While the addition of the LFCs was helpful, we imagine that their insights earlier in the project would have led to new possibilities for each CoP sub-group. As we identified the value of members who are closer to the learner perspective, we also want to highlight that including people in leadership and program director-type roles had unique affordances. Specifically, these leaders expanded our opportunities for creating events and reaching more expansive audiences. For example, the ethics table at BMES was sponsored by both the Education Division and the Ethics.

Expanded engagement of students and future educators of ethics is important too. In this same vein, we found that not only did we need more people who had prior experience teaching BME ethics in our community, but we also wanted to learn from those that were the learners and the next generation of ethics culture leaders (e.g. graduate and undergraduate students). This may seem obvious, but as it was not originally in our purview, we did not realize this omission until we hosted a table at BMES. At this table, we discovered that students enjoyed supporting our efforts and often were the ones that would stop by and actively engage. Additionally, students in our own classrooms who became interested in our work would join our labs but often found purpose in supporting and even leading some of the CoP events.

We are members too. Early on, in 2022, we had conducted a special session at ASEE that was co-sponsored by the Biomedical Engineering Division (BED) and the Engineering Ethics Division (ETHICS). We did not consider an activity of the CoP at the time, but in 2025

we convened another special session at ASEE. As facilitators, we interacted with this group of interdisciplinary individuals differently. Recognizing that we were part of the CoP and not simply research informants inherently changed how we approached and engaged with the audience. While both were intended to be discursive idea-generating sessions, the second felt more collaborative and less instructional, thus leading to a stronger sense of shared community.

Engaging practitioners during research projects can provide momentum. Even though this was an original objective, we found that engaging a CoP throughout a research process supported validating emergent findings and even driving research forward. We intentionally set out to have the CoP serve as validation process role for our research. We also set out with the aim of translating research-to-practice through the CoP. It is clear to us that engaging a CoP achieved both goals effectively. Even before we began generating data, convening with the CoP helped us identify opportunities to improve our methods and approaches to our research. The CoP members contributed to enhancing recruitment approaches, distributing informational surveys, and refining interview protocols. We believe that we captured far more meaningful information and engaged a more diverse set of participants than we would have if we had we just depended on our own team and three research advisory board members. While some research advisory members can also serve in these roles, that is a rare situation. We learned that engaging a CoP, especially the LFC subgroup, deepened the examination of research in progress and led to added value and insight more frequently and more often than past approaches with advisory boards or even conference disseminations.

A CoP is an ever-evolving membership and can expand in scope. We recently attended the IEEE-Ethics conference as a team. While all of us have now worked on several research projects in BME Ethics and Ethics Education, at this conference we found we were no longer just starting conversations, but rather we were picking them up with many of these colleagues that we are now seeing multiple times per year. Today, there are many more individuals expressly devoting their time and focus on BME Ethics. It is a subtle shift, as these colleagues are also not new to the convenings but the intentionality and regularity of the specific focused engagement around BME ethics discussions, research, and education seems to have expanded collective readiness to continue to expand community, activities, and the value of ethics education in engineering.

Closing Discussion

We hope this study will support others in their own efforts around CoPs. In this discussion, we offer suggestions for fostering CoPs in engineering ethics. We then describe our own future work and planning, reflecting the ongoing and iterative nature of CoP development.

Suggestions for Implementing Communities of Practice

First, in this study we shared a theory of change (i.e., **Figure 1**). This theory and its components evolved during the implementation of the CoP, with shifts in membership, activities, and both intended and incidental outcomes. In our lessons learned section of this paper, we highlighted how membership and activities aspects evolved, why, and aspects that we may have conducted differently. We hope that this theory of change and these lessons learned can serve as a reference to others as they develop CoPs in engineering ethics or related areas.

Second, we described how the BME Ethics CoP has developed and how it has contributed to supporting our associated research project. We argue that others, particularly those who receive research funding, might use this study as a guide as implement efforts like CoPs to (1) continuously engage leaders in a topical area with educational connections, (2) ensure findings resonate with a range of lived experiences, and (3) to identify how best to translate research findings to practice.

Third, a CoP can promote implementation of research findings into engineering education and applied ethical practice, more broadly, but this is largely contingent on who is included in and who actively participates in the CoP. Ensuring inclusive participation requires effective strategies for broadening participation. We discovered key groups who from our CoP, like students and faculty from different ranks, who we purposefully included in time. Others should consider whether they have the “right” type and amalgamation of participants. We encourage others to think about who should be part of their CoPs: students, researchers, and educators.

Fourth, we iterated on efforts to ensure the CoP activities were appropriately situated, including both place- and time-sensitive. For example, CoP developers should build activities into adjacent activities that participants are already engaging in. For example, we began pursuing efforts for participants to gather at professional conferences and convenings, like coffee and networking sessions. When participants represent distinct groups, co-sponsoring events becomes effective. For example, we have pursued dual-sponsored special sessions at ASEE.

Finally, CoPs can support the implementation of research findings into tangible norms and practices. Examples pertinent to ethics can include revisions to ethics codes, application or revisions to educational frameworks, and development and implementation of new resources that are responsive to community needs.

Our Future Work

First, we will continue to share results and gain input from LFC members through convenings at BMES and a series of final annual LFC and Advisory board summits in Spring and Summer 2026. The goal for BMES is to further integrate findings into BME ethics education and training spaces. The goal for the final summits will be to gain feedback on how this integration works and further finalize heuristics and educational approach tools and resources.

Second, we will continue to cultivate and expand our CoP membership. This paper serves as an invitation for interested others to join us as we continue to add value and support BME ethics culture development. In addition, we will continue other efforts to recruit new membership to continue to add depth and breadth to the CoP around BME, ethics, and education. In particular, prospective members include (a) students including graduate and undergraduate representatives, (b) early-career faculty and teaching instructors, and (c) program or institutional leaders.

Third, we will continue to iterate on our CoP development processes to ensure member perceived value. While this paper reflects our systematization of experiences analysis of our experiences in forming and cultivating this BME Ethics CoP here, we are now also keen to conduct additional explorations and analyses of the CoP development process and member perceived value using additional methods of assessment. Thus, we will continue to reflect on our experiences as well as begin engaging our members to understand their experiences as well.

Finally, as it was our original objective in forming the CoP to create opportunities for greater research to practice and BME ethics education impact, we will continue working with our CoP colleagues to translate and implement research findings into educational curricula.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant Nos. 1737303 and 2124953. 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.

References

- [1] Ó. J. Holliday, "Systematization of experiences, research and evaluation: Three different approaches." *The international journal for global and development education research*, 1, 71-84, 2012.
 - [2] A. Katz, "An inquiry into the nature and causes of the state of U.S. engineering ethics education," Doctorate, Purdue University, 2019.
 - [3] J. L. Hess and G. A. Fore, "A systematic literature review of US engineering ethics interventions," *Science and Engineering Ethics*, vol. 24, no. 2, pp. 551-583, 2018.
 - [4] A. Katz and D. Knight, "Factors related to faculty views toward undergraduate engineering ethics education," in *2017 ASEE Annual Conference & Exposition, (Columbus, Ohio), ASEE Conferences*, 2017.
 - [5] D. G. Johnson, "Can engineering ethics be taught?," in *The bridge: Linking engineering and society*. Washington, DC: National Academy of Engineering, 2017.
 - [6] National Academy of Engineering, *Infusing ethics into the development of engineers: Exemplary education activities and programs*. Washington, DC: The National Academies Press, 2016.
 - [7] P. Sharp, S. Hockfield, and T. Jacks, "Convergence: The future of health," *Science*, vol. 355, no. 6325, pp. 589-590, 2017.
 - [8] R. L. Stelter, J. B. Kupersmidt, and K. N. Stump, "Establishing effective STEM mentoring relationships through mentor training," *Annals of the New York Academy of Sciences*, vol. 1483, no. 1, pp. 224-243, 2021.
 - [9] C. Tanenbaum, *STEM 2026: A vision for innovation in STEM education*. Washington, DC: US Department of Education, 2016.
 - [10] P. Rubbo, C. L. Helmann, C. Bilynievycz dos Santos, and L. A. Pilatti, "Retractions in the Engineering Field: A Study on the Web of Science Database," *Ethics & Behavior*, vol. 29, no. 2, pp. 141-155, 2019.
 - [11] D. Hicks, P. Wouters, L. Waltman, S. De Rijcke, and I. Rafols, "Bibliometrics: the Leiden Manifesto for research metrics," *Nature News*, vol. 520, no. 7548, pp. 429-431, 2015.
 - [12] J. E. Monzon and A. Monzon-Wyngaard, "Professional ethics in Biomedical Engineering practice and research," presented at the IEEE EMBS Conference, Vancouver, British Columbia, 2008.
 - [13] C. Mitcham, "Ethics in bioengineering," *Journal of Business Ethics*, vol. 9, no. 3, pp. 227-231, 1990.
 - [14] J. Carreyrou, *Bad Blood: Secrets and Lies in a Silicon Valley Startup*. New York, NY: Alfred A. Knopf, 2018.
- M. Jeske, "Lessons from Theranos: Changing narratives of individual ethics in science and engineering," *Engaging Science, Technology, and Society*, vol. 6, pp. 306-311, 2020.

- [15] A. Pendyal and J. S. Ross, "The Bleeding Edge: Documenting Innovation and Injury in the Medical Device Industry," *Jama*, vol. 322, no. 3, pp. 190-192, 2019.
- [16] J. Anderson, "You Can't Code for Humanity: AI, Algorithms, and the Bias of Machine Learning," *Resources for Gender and Women's Studies*, vol. 44, no. 1/2, pp. 18-19, 2023.
- [17] A. O. Brightman *et al.*, "Applying Phenomenography to Develop a Comprehensive Understanding of Ethics in Engineering Practice," *2018 IEEE Frontiers in Education Conference (FIE)*, San Jose, CA, USA, 2018.
- [18] J. L. Hess, D. Kim, and N. D. Fila, "Critical Incidents in Ways of Experiencing Ethical Engineering Practice," *Studies in engineering education*, vol. 3, no. 2, Mar. 2023.
- [19] N.D. Fila, C.B. Zoltowski, J.L Hess, *et al.* "How do Engineers Experience Ethics in Practice?: A Phenomenographic Investigation of Engineers in the Health Products Industry." *Science and Engineering Ethics*, (in press) 2026.
- [20] J.L. Hess, N. D. Fila, A. O. Brightman, A. J. Kerr, Sowmya Panuganti, and T. A. Ramsey, "BOARD # 404: NSF ER2 Project: Exploring the Variation in Understanding and Experiences with Ethical Engineering Research among Faculty in Biomedical Engineering," *Doi.org*, Jun. 22, 2025.
- [21] J. Lave and E. Wenger, *Situated learning: Legitimate peripheral participation*. Cambridge university press, 1991.
- [22] E. Wenger, *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press, 1998.
- [23] J. Lave and E. Wenger, "Legitimate peripheral participation in communities of practice," in *Supporting lifelong learning: Perspectives on learning*, R. Harrison, F. Reeve, A. Hanson, and J. Clarke Eds. London: The Open University, 2002, ch. 7, p. 111.
- [24] C. Tanenbaum, *STEM 2026: A vision for innovation in STEM education*. Washington, DC: US Department of Education, 2016.
- [25] L. A. Watson, A. K. Bentley, H. J. Eppley, and S. Lin, "Building an online community of practice for the evolution of Effective, Evidence-Based Teaching Practices: 15 years of improving Inorganic Chemistry Education," in *ACS symposium series*, 2020, pp. 127–142.
- [26] K. Ryker, L. Lukes, A. Klyce, K. Cheek, N. LaDue, and P. McNeal, "The geoscience education research (GER) community of practice: a brief history and implications from a needs assessment survey," *Journal of Geoscience Education*, pp. 1–15, Jun. 2024.
- [27] R. Streveler, K. Smith, and R. Miller. "Enhancing engineering education research capacity through building a community of practice." *2005 Annual Conference*. 2005.
- [28] B. M. Capobianco and A. Feldman, "Promoting quality for teacher action research: lessons learned from science teachers' action research," *Educational Action Research*, vol. 14, no. 4, pp. 497–512, Nov. 2006.
- [29] E. Crede, M. Borrego, and L. McNair, "Application of Community of Practice Theory to the preparation of engineering graduate students for faculty careers," *AEE Journal*, vol. 2, no. 2, pp. 1–22, Jun. 2010.
- [30] R. Adams, CGP Berdanier, PA Branham, N Choudhary... "A community of practice approach to becoming an engineering education research professional," *2014 ASEE Annual Conference & Exposition*, 2014.
- [31] I. Varlamis and I. Apostolakis, "The educational role of Communities of Practice in Biomedical Engineering," in *5th European Symposium on Biomedical Engineering*, Patras, Greece, 2007.

- [32] S. Naidoo and A. T. Vernillo, "Adapting a community of practice model to design an innovative ethics curriculum in healthcare," *Medical Principles and Practice*, vol. 23, no. Suppl. 1, pp. 60–68, Aug. 2013
- [33] J. Rogers, "Legal ethics education: Seeking-and creating-a stronger community of practice." *Geo. J. Legal Ethics* 36: 61, 2023.
- [34] J. C. Collins and T. R. Harris, "The VaNTH ERC: A vehicle for continuing education in bioengineering," *Industry and Higher Education*, vol. 15, no. 5, pp. 333-339, 2001.
- [35] P. L. Hirsch, B. L. Shwom, C. Yarnoff, J. C. Anderson, D. M. Kelso, G. B. Olson, and J. E. Colgate, "Engineering design and communication: The case for interdisciplinary collaboration," *International Journal of Engineering Education*, vol. 17, no. 4/5, pp. 343-348, 2001.
- [36] D. S. Cordray, T. R. Harris, and S. Klein, "A research synthesis of the effectiveness, replicability, and generality of the VaNTH challenge-based instructional modules in bioengineering," *Journal of Engineering Education*, vol. 98, no. 4, pp. 335-348, 2009.
- [37] T. Martin, K. Rayne, N. J. Kemp, J. Hart, and K. R. Diller, "Teaching for adaptive expertise in biomedical engineering ethics," *Science and Engineering Ethics*, vol. 11, no. 2, pp. 257-276, 2005.
- [38] J. L. Hess *et al.*, "Transforming Ethics Education Through a Faculty Learning Community: 'I'm Coming Around to Seeing Ethics as Being Maybe as Important as Calculus,'" *Science and Engineering Ethics*, vol. 30, no. 5, Sep. 2024.
- [39] L. Gelles, I. Villanueva, and M. Di Stefano, "Mentoring is ethical, right?": Women graduate students & faculty in science & engineering speak out," *Int. J. Gender, Sci. Technol.*, vol. 11, no. 1, pp. 108–133, Jun. 2019.
- [40] S. Prashanth, "Analyzing Ethics Education Strategies in Biomedical Engineering Programs," *The Journal of Purdue Undergraduate Research*: Vol. 15, Article 20, Dec. 2025.