Conceptualizing the Institutional Transformation Approach to STEM Ethics Education: An Exploratory Study of NSF-Funded Institutional Transformation Projects

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Introduction

There is consensus that the integration of ethics into STEM curricula is critical for cultivating cultures for ethical practices in STEM research. We argue that the establishment of the Ethics and Responsible Research (ER2) program, previously known as Cultivating Cultures for Ethical STEM (CCE-STEM), at NSF was driven by a *cultural perspective* on ethics education. According to the most recent version of its solicitation,

> A comprehensive approach to ethical STEM not only influences individual behavior, but it also maintains and fosters an ethical, equitable and just culture within an organization or research field. Thus, investigators submitting to the program are encouraged to examine organizational and cultural factors that influence ethical and responsible research practice (NSF, 2023).

Such a cultural approach to STEM ethics education is primarily essentially *holistic* and *pragmatic*. It adopts a holistic approach by recognizing that ethics education occurs within a cultural context, and that an individual's ethical conduct can be both influenced and constrained by their research or workplace contexts. Additionally, it adopts a pragmatic perspective by viewing the objective of ethics education not merely as influencing individual ethical reasoning (as is commonly anticipated in most STEM ethics initiatives) but also as an endeavor to engender more systematic, institutional-level transformations in the ethical climate in which individual scientists and engineers work. Moreover, the cultivation of an ethical research/workplace culture is considered imperative for fostering sustainable ethical transformation at both the individual and organizational levels within the campus community.

Based on our initial search, while there have been seven institutional transformation projects funded through NSF's CCE STEM or ER2 program, *there has been a scarcity of research that systematically compares these funded projects and seeks to derive broader theoretical insights regarding the institutional transformation approach to STEM ethics education*. The purpose of this paper is to offer initial insights into the lessons that can be drawn from these funded projects, with the aim of contributing to the theoretical understanding of the institutional transformation approach to STEM ethics education.

In particular, this paper seeks to investigate the following research questions:

(1) What motivates researchers to opt for an institutional approach over an individualistic one?

(2) What theoretical frameworks do researchers employ to tackle institutional transformation?

Finally, this paper will outline how our recently awarded institutional transformation grant can benefit from these results. We intend to gather data using three major methods: (1) public summaries of these projects published on NSF's website; (2) publications listed on each project's dedicated webpage on NSF's website as well as additional searches in Google Scholar; and (3) news articles and related commentaries available on the internet pertaining to these projects.

We anticipate that the initial findings of this study can offer valuable insights for engineering education researchers, higher education administrators, and policymakers. These insights can aid

in the development and implementation of more efficient, impactful models for fostering institutional transformation of ethical STEM cultures within and beyond their campuses.

Literature Review

One of the earliest movements to institutionalize ethics education is the Ethics Across the Curriculum (EAC) movement, which began over thirty years ago and included the founding of some of the nation's premier ethics centers. Yet there is little literature on the role of ethics centers within academic institutions and even less on the systematic development or assessment of ethics education or EAC programs. While ethics centers are housed within a variety of colleges and schools across universities, the majority are in the humanities or social sciences (e.g., journalism or business) with a smattering in medical schools (Moore, 2023). In contrast, the historical NIH and NSF emphasis on responsible research and federal mandates for research universities seeking federal funding often led to RCR education being housed in legal or compliance divisions, such as ethics and compliance offices, research divisions, such as grant development offices, or STEM academic units, such as schools of engineering or medicine (Geller, Boyce, Ford, & Sugarman, 2010). As Resnick (2014) argues, this institutional bifurcation between the traditional teaching of ethics in the humanities to instill understanding and promote critical reflection, and the emphasis within the sciences to govern behaviors via research conduct and professional codes creates problems when assessing ethics education.

The emphasis on institutional factors in ethics education in this paper can be seen as a response to a small but consistent area of scholarship pointing out its importance. Langlais (2012) emphasizes the importance of examining institutional, organizational, and contextual factors, and a recent special issue of *Teaching Ethics* (fall 2021) on the role of ethics centers reexamine the institutional factors affecting ethics education and assessment. Boyd and Newton (2011) argue that rapidly changing features of emerging technologies requires a re-examination of institutional administration and policies for effective ethics education. Schultz and Steele (2023) provide insights from business organizational models to suggest that the institutionalization of artificial intelligence (AI) ethics must attend to multiple factors such as (a) accurate identification and engagement of stakeholders, (b) rigorous inclusion of moral philosophy to avoid anti-regulation tactics such as "ethics washing," (c) standardized reporting to maintain quality control and accountability, (d) standardized curricula for accreditation and quality assurance, and (e) the internalization of institutional self-governance. Mitcham and Engelhardt (2019) mention several of these factors, and additionally suggest evaluating the relation between RCR and engineering ethics education and EAC programs.

While the holistic ethics intervention framework centers on engineering ethics education at the course level, Martin et al.'s (2021) multi-level framework delves into how faculty, serving as decision-makers in engineering education, perceive and establish connections across different levels of the engineering ethics education system. This includes not only the individual (e.g., instructor's practices and beliefs) level but also institutional (e.g., ethics education policies in programs, departments, or institutions), policy (e.g., policies adopted by governmental and accrediting bodies or funding agencies), and cultural (e.g., values and norms in engineering education and practice) levels.

Finally, the institutional epidemiology theory explores ethics education on a community or institutional level, investigating the specific locations within the institution where ethical learning takes place. It can function as a tool for a critical examination of: (1) the values inherent

in administrators' decision-making; (2) the impact of institutional characteristics and cultures on the planning of the ethics curriculum; and (3) the interplay between the ethics curriculum and the broader STEM curriculum.

Methods

We used NSF's award search function to conduct an initial search for NSF CCE STEM and ER2 IT grants (https://www.nsf.gov/awardsearch/advancedSearch.jsp) from 2016 to 2023. During the search process, we opted for SBE (Directorate of Social, Behavioral, and Economic Sciences) as the designated NSF organization, specifying "Institutional Transformation" as the keyword. Our initial search returned 5 results (3-7 in Table 1). In addition to using the NSF search function, we conducted an online search with Google using the keywords "NSF CCE STEM ER2 Institutional Transformation." This supplementary search led to the identification of institutional transformation grants from Georgia Tech and IUPUI that were not initially returned in the NSF search results. These are nos. 1 and 2 in Table 1.

ID	Award Name	Institution	Duration
IT #1	Institutional Transformation: The Role of Service Learning and Community Engagement on the Ethical Development of STEM Students and Campus Culture	Georgia Tech	2016-2021
IT #2	Institutional Transformation: Enhancing IUPUI STEM Curriculum through the Community-Engaged Learning and Ethical Reflection Framework (I-CELER)	Indiana University–Purdue University Indianapolis (IUPUI)	2017-2021
IT #3	Institutional Transformation: Cultivating an ethical STEM culture through an integrated undergraduate general education	Virginia Tech	2017-2023
IT #4	Institutional Transformation: VERITIES - Virtue-Based Education for Responsibility and Integrity to Increase Excellence in STEM	Michigan State University	2020-2025
IT #5	Institutional Transformation: Intersections of Moral Foundations and Ethics Frameworks in STEM Enculturation	University of Central Florida	2020-2025
IT #6	Institutional Transformation: Anticipating Undesirable Consequences of Computer Science Research	University of Washington	2023-2028
IT #7	Institutional Transformation: Transforming Cultures of Responsible Research through the Development of Ethics Expertise and Self-Efficacy	Virginia Tech	2023-2028

	among Faculty through Social Networks		

Table 1 NSF CCE STEM (ER2) funded institutional transformation grants

After identifying the seven institutional transformation awards, we first analyzed the public summaries of these projects published on NSF's website. In addition, we further reviewed the publications listed on each project's dedicated webpage on NSF's website. Finally, we also searched and reviewed news articles and related commentaries available on the internet pertaining to these projects. We coded the three data sources according to the two research questions outlined in the methods section.

Findings

Project Motivation

It is clear that every project supported by the CCE STEM or ER2 program is dedicated to the exploration and evaluation of innovative methods for fostering ethical researchers within STEM disciplines. In addressing Research Question #1 "what motivates researchers to opt for an institutional approach over an individualistic one," our focus lies in investigating the specific reasons behind the preference of *institutional* approaches over *individualistic* ones for ethics education within these institutional transformation projects.

A major motivation for four IT projects listed in Table 1 is the interest in expanding or institutionalizing ethics pedagogies that have been implemented previously on a smaller scale, such as within individual courses, research centers, or departments. For instance, IT #1 is dedicated to developing a campus-wide service-learning program (a pedagogy that has been implemented in individual STEM courses) focused on community engagement and sustainability and assessing the impact of such programs across the institution. In a parallel effort, IT #2 integrates ethical reflection and community engagement, both tested and implemented in the context of individual STEM courses, into the curricula of two departments on campus: Earth Sciences and Biomedical Engineering. IT #4 aims to institutionalize a virtue-based ethics education approach that has been previously tested and implemented at a research center on their campus for seven years.

In contrast, the other four IT projects listed in Table 1 appear to be motivated by their interests in exploring factors that contribute to effective STEM ethics education from *holistic* or *institutional cultural* perspectives. Institutional transformation projects 3, 5, 6 and 7 acknowledge the significance and effectiveness of institutional cultures and structures, including researchers' virtual communities and social networks, in cultivating ethically competent STEM researchers and future STEM professionals. IT #3 acknowledges the university as "a networked community of individuals and groups with strengths, values, and subcultures" (Biscotte & Mouchrek, 2020), where each member and unit possess assets that can contribute to ongoing community development for teaching ethical reasoning in general curriculum courses. IT #5 examines how the interaction between personal values and explicit content and experiences of the formal ethics curriculum affects students' moral development. IT #6 highlights the importance of knowledge sharing and collaboration among computer science researchers in virtual communities to identify and address potential undesirable consequences of their work. By sharing best practices and developing new solutions, researchers can help computer scientists use their research for societal

good. Finally, IT #7 leverages faculty social networks to expand the impact of the research ethics training program, promoting a culture of responsible research across disciplines and institutions.

Theoretical Frameworks

Similar to the findings in the motivation section above, there are two groups of theories or theoretical frameworks used by these institutional transformation projects. If the major purpose of an IT project is to institutionalize ethics pedagogies previously implemented and tested on a smaller scale, such as individual classes, it is very likely that the theoretical frameworks for these projects are mostly concerned with *individualistic moral development and growth*. These projects often largely assume that widespread implementation of an engaging, reflective, and effective ethics pedagogy among individual STEM trainees will contribute to a positive institutional culture that promotes responsible research practices. However, it is important to consider the specific mechanisms by which individual learning translates into broader cultural change, as well as potential limitations and the influence of other factors.

For instance, the public summary of IT#1 does not include an explicit theoretical framework. However, based on a conference paper the research team published, it seems that a major theoretical framework they used could be called “curriculum theory” (Erwin, Borenstein, Newstetter, Potts, & Zegura, 2018). More specifically, it recognizes the *curriculum structure* as a significant factor influencing individual students' development of professional identity and ethical awareness. Building upon Erin Cech’s work on moral disengagement, their research examines which learning activities can help to mitigate the decline in interest about public welfare among engineering graduates. Their work seeks to “identify which specific facets of community engagement (CE) activities, including service learning (SL), contribute to or fortify the concern that engineering and other STEM students have for the well-being of the public” (Erwin, Borenstein, Newstetter, Potts, & Zegura, 2018).

IT #2 constructed a theoretical framework, the Integration of Community-Engaged learning and Ethical Reflection (I-CELER), drawing upon two bodies of philosophical literature: John Dewey's pragmatic ethics and care ethics (Hess & Fore, 2018). A fundamental premise of this project is grounded in the *moral development of individuals*: community-engaged learning contexts offer greater potential for ethical growth compared to non-community engaged strategies, such as traditional lecture-based classes (Hess & Fore, 2018). Specifically, within community-engaged learning contexts, instructors can leverage events to prompt students' reflection-on-action. This allows students to delve into the ethical dimensions of their behaviors and thoughts, and to apply otherwise abstract philosophical concepts in practical settings.

The theoretical framework of IT #4 is grounded in a scientific virtue-theoretic account, supported by a national study encompassing data from over 1,100 scientists (McLeskey, Berling, O'Rourke, & Pennock, 2020). This study identified a cohesive set of values essential to individual scientists, including attentiveness, objectivity, perseverance, skepticism, meticulousness, and humility towards evidence. Subsequently, the research team developed modules aimed at training graduate students and faculty, and helping them to recognize how each virtue connects scientific identity with excellence in practice, using a guided dialogue framework to do so (McLeskey, Berling, O'Rourke, & Pennock, 2020). The public summary of IT #4 briefly mentions that the researchers also plan to train some faculty to serve as committed exemplars to support changes in ethical culture. However, this approach is still deeply grounded in virtue ethics, which assumes

that virtuous tendencies demonstrated through individual actions and interactions can exert moral influence on those surrounding them.

In summary, these institutional transformation projects suggest that institutional ethical cultural change hinges on the moral development and growth of individuals. However, we are also interested in exploring whether there are IT projects whose theoretical frameworks are grounded in an understanding of the *institutional aspects* of ethics education, the premise that effective ethics education in STEM depends largely on institutional cultures and structures.

IT #3 focuses on implementing and assessing a university-wide effort to integrate ethical reasoning into the general education curriculum. The research team used an Asset-Based Community Development (ABCD) framework to facilitate the transformation of institutional ethical cultures. The ABCD framework takes a strength-based approach to institutional change.

Its objective is to identify community assets and strengths, fostering opportunities for relationship-building and asset mobilization, thereby enabling continuous reflection and improvement. Viewed through an ABCD lens, a university can be conceived as a community comprising individuals (students, faculty, staff, administration, and local residents), associations (student government, faculty committees, housing and residence life, community coalitions, and non-profit organizations), and institutions (academic colleges, dining and residence halls, administrative offices, town hall, and local parks), all collaborating toward common objectives of student learning and development (Biscotte & Mouchrek, 2020). Therefore, promoting effective institutional transformation of ethical cultures requires educational reformers to recognize that "every individual, association, and institution has assets to contribute to ongoing community development" and they are not clients that need to "buy in" but are citizens ready to participate in reforms.

IT #5 constructs its own theoretical framework, using the lens of institutional epidemiology. The researchers took a holistic approach to examining the totality of students' formal ethical learning experiences in the curriculum. Their rationale for this approach is to gain insight into how undergraduate students are exposed to ethics, which can inform our understanding of the extent to which they are influenced by an interest in ethics literacy and the level of "immunity" they develop against unethical and unprofessional conduct (Beever, Kuebler, & Collins, 2021). Two limitations are identified in this approach by the research team: (1) their work only examined the explicit, formal curriculum not implicit, informal curriculum, and (2) certain course were not included in the data (e.g., graduate courses, capstones, independent studies, study abroad courses, and internships) (Beever, Kuebler, & Collins, 2021).

IT #6, a more recently awarded project, has limited information available online. Based on its NSF public summary page and one conceptual paper published on Arxiv.org, we found that their approach to generating institutional impact is based on ideas similar to a virtual community of practice (Pang, Grossman, Kohno, & Reinecke, 2023). Their approach involves developing an online collaborative learning system that empowers computing researchers to access and contribute to ethics cases, engage in collaborative brainstorming, and review potential undesirable consequences of each other's computing projects. Additionally, the system provides access to an ethics advisory board for further guidance and advice (Pang, Grossman, Kohno, & Reinecke, 2023).

IT #7 is another newly awarded project. Their theoretical framework is based on a theory of social norms (Bicchieri, 2017). This project specifically leverages the social networks of faculty to extend the reach and impact of their training program across the campus. Through a combination of surveys and project ambassadors, this project seeks to identify the "reference networks" of faculty, which comprise influential faculty members whose opinions significantly influence the behaviors and decisions of others. By offering a multi-session training program to these influential faculty members, the project aims to catalyze a transformation in institutional research culture through both informal and formal interactions between these faculty members and others.

Table 2 summarizes the motivations and theoretical frameworks of all seven institutional transformation projects.

ID	Award Name	Motivation	Theoretical Framework
IT #1	Institutional Transformation: The Role of Service Learning and Community Engagement on the Ethical Development of STEM Students and Campus Culture	Institutionalizing ethics pedagogies previously implemented at a smaller scale	Curriculum Theory
IT #2	Institutional Transformation: Enhancing IUPUI STEM Curriculum through the Community-Engaged Learning and Ethical Reflection Framework (I-CELER)	Institutionalizing ethics pedagogies previously implemented at a smaller scale	Integration of Community-Engaged learning and Ethical Reflection (I-CELER)
IT #3	Institutional Transformation: Cultivating an ethical STEM culture through an integrated undergraduate general education	Leveraging the influence of institutional cultures and structures to facilitate impactful ethical cultural change	Asset-Based Community Development (ABCD)
IT #4	Institutional Transformation: VERITIES - Virtue-Based Education for Responsibility and Integrity to Increase Excellence in STEM	Institutionalizing ethics pedagogies previously implemented at a smaller scale	Scientific Virtue-Theoretic Framework
IT #5	Institutional Transformation: Intersections of Moral Foundations and Ethics Frameworks in STEM Enculturation	Leveraging the influence of institutional cultures and structures to facilitate impactful ethical cultural change	Institutional Epidemiology

IT #6	Institutional Transformation: Anticipating Undesirable Consequences of Computer Science Research	Leveraging the influence of institutional cultures and structures to facilitate impactful ethical cultural change	Virtual Community of Practice (or Knowledge Sharing and Collaboration in the Virtual Space)
IT #7	Institutional Transformation: Transforming Cultures of Responsible Research through the Development of Ethics Expertise and Self-Efficacy among Faculty through Social Networks	Leveraging the influence of institutional cultures and structures to facilitate impactful ethical cultural change	Social Norms Theory

Table 2 Motivations and theoretical frameworks for NSF CCE STEM / ER2 projects

Discussion and Conclusion

This paper investigates the motivations and institutional approaches to ethics education reforms behind seven NSF CCE STEM (ER2) IT projects awarded between 2016 and 2023. It provides an overview of the theoretical frameworks adopted by each project. Based on these preliminary findings, we identified two approaches to justify the adoption of institutional approaches to STEM ethics education reforms: (1) engaged ethics pedagogies, such as community-engaged learning, self-reflective moral learning, and virtue-based education, which emphasize the moral development and growth of individuals, can be implemented at the institutional level to extend their impacts; and (2) institutional characteristics and resources can be leveraged to facilitate impactful ethical cultural change across the campus.

These motivations have further affected the theoretical frameworks of each institutional transformation project. For instance, projects that attempt to institutionalize engaged ethics pedagogies often adopt theoretical frameworks that focus on the moral learning experiences (e.g., how students experience the curriculum, how students morally grow and become ethical professionals) and moral psychology (e.g., virtues fundamental for good scientists) of individual students. Four institutional transformation projects have explicitly adopted holistic or institution-related theories to guide research and implementation designs. These institutional theories could be further categorized into three groups:

- Institutional curriculum: IT #5 examines the structure of institutional curriculum (where ethics is taught) and how it contributes to the formation of students' moral identity.
- Faculty networks: IT #6 focuses on the role of the virtual community of practice among faculty, whereas IT #7 leverages faculty's social networks to transform institutional culture.
- University governance structure: IT #3 conceptualizes the university as a community comprising individuals (students, faculty, staff, administration, and local residents), associations (student government, faculty committees, housing and residence life, community coalitions, and non-profit organizations), and institutions (academic colleges,

dining and residence halls, administrative offices, town hall, and local parks) that all collaborate toward common objectives of student learning and development.

In summary, this paper represents an initial endeavor to reflect on the motivations and theoretical underpinnings of institutional transformation ethics education projects funded through NSF's CCE/ER2 program. We hope that our findings will inspire other STEM education and ethics education researchers, as well as university administrators, to engage in thoughtful and critical consideration of how to systematically, scientifically, and effectively transform institutional ethics culture. Future research should focus on developing rigorous methods for systematically comparing the design and implementation of these IT projects, which could include conducting a meta-review of the findings from these projects. Such efforts will contribute to a more comprehensive understanding of how STEM students develop their personal and professional moral identities, and how this development is influenced by institutional factors, and vice versa.

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