A Systematized Literature Review of Scholarship on Ethical Development and Perspective-taking in Engineering Students

Brooks M. Leftwich*
Purdue University
bleftwic@purdue.edu

Abstract

This report is a systematized literature review of published journal articles about frameworks, models, theories, and approaches that support one's ethical development with a focus on perspective-taking as an integral part of that experience. Ethical development is essential to engineering students because the decisions they make – whether good or bad, right, or wrong – impact individuals, communities, the environment, and even the world. This systematized literature review searched for relevant articles in engineering and education domains to inform the scope of the analysis. For the engineering database search, the records produced content related to current pedagogical approaches used in the classroom and outside the classroom while the education database search provided supplemental articles connecting perspective-taking and ethical development. A screening of 31 records produced five articles with four unique approaches related to perspective-taking and its relationship to ethical development and the ABET Criterion 3.4 contexts of recognizing ethical and professional responsibilities while making informed and considerate judgments. These four perspective-taking approaches could offer unique opportunities for instructors to adapt their current ethics content or create new, revitalized content that uses perspective-taking as a process to achieve the learning goals of understanding the global, economic, environmental, and societal contexts of engineering solutions.

Index Terms: ABET Accreditation Criteria, Engineering, Ethical development, Literature review, Perspective-taking

Introduction

Several engineering organizations state that engineering professionals need to act ethically, as seen in [1]–[3]. Specifically, the National Society of Professional Engineers' (NSPE) sixth Fundamental Canon in [1, p. 3] says that engineers need to "conduct themselves honorably, responsibly, ethically, and lawfully…". However, there seems to be no current consensus on a pedagogical framework for teaching engineering ethics connected with these statements. The Accreditation Board for Engineering and Technology, Inc. (ABET) Engineering Criteria 2000 created Criterion 3.f to formalize engineering ethics education and bring about a standard of professional and ethical content in engineering programs [4]. Now revised and referred to as Criterion 3.4, it states in [5, p. 5] that accredited engineering programs must document student outcomes related to "*an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.*"

Yet without well-defined and accessible frameworks for teaching engineering ethics, engineering programs will continue to struggle with fully meeting Criterion 3.4 and the expectations of the NSPE and other stakeholders. Frameworks focused on perspective-taking may provide a solution to this problem as well as extend into application domains such as design, communication, and coordination. Kahn and Zeidler published a conceptual analysis of perspective-taking and developed the Socioscientific Perspective Taking (SSPT) model which they state in [6, p. 27] "represents an emphasis on the development of a diverse suite of perspective-taking skills as well as the moral context, composed of reflective and reflexive judgment." This model builds on the Socioscientific Reasoning (SSR) construct created by Sadler et al. [7] which includes perspective-taking as one of its key skills and aims to fill the gap that SSR had in assuming that moral development occurred rather than explicitly identifying it [6]. A perspective-taking framework like SSPT could both standardize engineering ethics curriculum while also allowing faculty the flexibility to choose which "moral context" to set the content in, such as global, economic, environmental, and/or societal.

Alternatively, Garrigan et al. introduced in [8] the Social Information Processing-Moral Decision-Making (SIP-MDM) framework. This framework specifically links perspective-taking to moral development as a skill to be used when processing information [8]. Garrigan et al. emphasize the role of perspective-taking when they say in [8, p. 10], "Perspective taking is important for moral development as it allows for the thoughts and feelings of others to be taken into account when making moral decisions, as attributions of intent can affect how moral decisions are processed, and whether empathy is triggered." These two approaches demonstrate that scholars are recently thinking about the role that perspective-taking plays in ethical development, and this report aims to crystalize the small volume of current literature on the subject so that others can investigate this relationship further. For this report, I take both ethical and moral development to mean one's understanding of right and wrong conduct – where ethical development is more aligned with outside influences such as codes of conduct and moral development centers on internal influences such as personal principles. This report does not assign preference to one or the other, and I see developing understanding around both the ethical and moral contexts of engineering decision-making through perspective-taking as the intended outcome.

Perspective-taking, as used for this manuscript, is adapted from the American Psychological Association's definition in [9] as the act of looking at a situation from someone else's viewpoint, particularly the perspective of someone from another social, professional, or cultural role. Without considering the affected parties, or without understanding why they should consider the affected parties because of a lack of perspective, engineers risk making less ethical decisions. I believe that the goals of NSPE and ABET can be met through more intentional ethics education based on promoting and inspiring perspective-taking in engineering students which leads to a more honest, impartial, fair, and equitable society. This literature review aims to compile current research on the use of perspective-taking to inspire and promote ethical development. Some scholars have developed learning goals for ethical development as seen in [10, p. 564–565] as "ethical sensitivity and awareness; ethical judgment, decision-making, or imagination; [and] ethical courage, confidence, or commitment." These learning goals provide insight into the breadth of engineering work that contributes to a well-rounded engineer outside of the dominant

technical functions. Using perspective-taking as the focus could help develop these ethical skills in the classroom which would work towards answering the calls of NSPE and ABET.

Research Question

RQ: How is perspective-taking taught inside and outside the K–20 STEM classroom to increase ethical development as reported in the literature?

Literature Review

ABET Criterion 3.f: The Past and the Present

Before discussing ABET Criterion 3.f, now in 2021 named Criterion 3.4, it is important to detail the shift in intentional language and curriculum related to ethics/ethics-related topics in the U.S. before its approval. Stephan in [11] examined program requirements at 242 institutions for the 1996-97 academic year. His findings in [11, p. 460] showed that "less than 27% [of the 242 institutions] require[d] all their students to take any ethics-related course." Even of the less than 27% that had such a requirement, many of the programs with ethics requirements were covered in philosophy or religion classes at institutions with previous or current religious affiliations [11]. Stephan's statistics in [11] suggested that engineering students were not receiving adequate emphasis on ethical development, and ABET Criterion 3.f was implemented shortly after this study to better standardize ethics education requirements across engineering programs.

ABET Criterion 3.f, created as a part of the Engineering Criteria 2000, marks a pivotal shift in the engineering ethics education curriculum, as described in [4]. ABET Criterion 3.4 (an ability to recognize ethical and professional responsibilities…), and previously Criterion 3.f, is the guiding principle that engineering programs use to create and implement curriculum and pedagogy specifically related to ethics across the U.S. and abroad. Few would argue against the importance of practicing engineers recognizing their ethical and professional responsibilities in industry, but many engineering programs struggle with understanding the amount of course content needed to adequately meet this criterion [4]. Despite being dated to 2012, the sentiment in [4] is still seen anecdotally today when I ask my peers what their program implemented for ethics education.

To get a better sense of the landscape of engineering ethics education after Criterion 3.f, Hess and Fore in [10] carried out a systematic review of engineering ethics interventions described in peer-reviewed journal articles from 2000-2015. This systematic review indicated that the most common ethics interventions were exposure to codes/standards, case studies, and discussion activities while concluding in [10, p. 552] that the engineering education community "should continue exploring the relative merits of different approaches to ethics education in engineering."

Perspective-taking and its Potential Application

A framework focused on perspective-taking would be different from the most common approaches of using codes/standards, case studies, and discussions to teach ethics. Hess and Fore make three pedagogical suggestions in [10] that could utilize perspective-taking: integrating

micro-insertions of ethics across the curriculum, community-engaged approaches, and real-world strategies. Perspective-taking skills interface with many of the daily tasks of engineers in their interactions with clients and co-workers in efforts to meet project requirements such as communicating across disciplines (e.g. engineering to business) and understanding the needs of the client. Todd and Galinsky in [12] performed a literature review of the efficacy of perspective-taking as a strategy for improving intergroup relations and reducing bias in a psychological context. They stated in [12, p. 374] several benefits including "more favorable implicit and explicit intergroup evaluations, stronger approach-oriented action tendencies and positive non-verbal behaviors, increased intergroup helping, reduced reliance on stereotype-maintaining mental processes, and heightened recognition of intergroup disparities."

These benefits highlight the effect that teaching perspective-taking can have, and engineers will likely actualize these benefits if they use this skill in their decision-making during projects. Support for perspective-taking in students' ethics education is crucial to developing decision-making skills in the classroom before they transition to industry. Because of the lack of consensus on teaching engineering ethics, this systematized literature review identifies frameworks, models, theories, and approaches that are being used to teach perspective-taking.

Research Methods

This manuscript follows the methodological approach summarized by Grant and Booth in [13] as the systematized literature review which parallels a systematic literature review process without including comprehensive searches and/or quality assessments. Although important, both steps lie out of the scope for this project because of time and resource restrictions. To answer my research question, I began by developing a comprehensive yet precise search string to use for my database searches. The search string includes my main concepts of perspective-taking and ethical development as well terms related to the context of my question, specifically using a framework to teach perspective-taking to engineering students.

To begin synthesizing the current literature on perspective-taking and how it is (or could be) applied to engineering students' ethical development, I used Zakharov's method described in [14] for creating a Boolean search string starting with a table. Table I shows the construction of the search terms I used.

TABLE I
KEYWORD AND SEARCH STRING FORMATION

Keywords:	1	2	3	4	5
Original Keyword:	engineering	ethics	perspective taking	framework	teaching
Synonym/Related word:	STEM	ethical development	perspective-taking	model	education
	technology	ethical reasoning		theory	
		ethical decision making		approach	
		ethical decision-making			

From this formation stage, I used the following search strings detailed in Table II. I performed a database search in Engineering Village which compiles articles from COMPENDEX and Inspec. COMPENDEX describes itself in [15] as the most expansive and comprehensive engineering literature database and Inspec describes itself in [16] as one of the largest databases for engineering, physics, and computer science. Searching the COMPENDEX and Inspec databases informed the current state of perspective-taking and its relation to ethical development in science, technology, and engineering education and returned the greatest number of articles about this topic in the relevant literature. Of the 85 total records returned, 35 results were peer-reviewed journal articles. There were nine duplicate items between COMPENDEX and Inspec, so the final record count totaled 26. The keyword searches were initially left unlimited using the "WN ALL" search code. This search code applied the key terms from the search string within all subsets of the records (e.g., title, abstract, keywords), and it allowed for the widest breadth of records to be returned. Variations such as moral development instead of ethical development and role-taking instead of perspective-taking may be used in different parts of the article making the within-all search code the most relevant.

TABLE II
SEARCH STRINGS AND DATABASE RESULTS

Search String	Database	Initial Results	Peer-reviewed journal articles
(((((((engineering or STEM or technology) WN ALL) AND ((ethics OR ethical development OR ethical reasoning OR ethical decision-making OR ethical decision making) WN ALL)) AND ((perspective taking OR perspective-taking) WN ALL)) AND ((framework OR model OR theory OR approach) WN ALL)) AND ((teaching or education) WN ALL)))	COMPENDEX/Inspec	85	26
engineering or stem or technology AND (ethics or ethical development or ethical reasoning or ethical decision-making or ethical decision making) AND (perspective taking or perspective-taking) AND (framework or model or theory or approach) AND (teaching or education)	EBSCOhost ERIC	8	5

I also performed a database search in EBSCOhost ERIC using the second search string in Table 2. ERIC includes publications from the field of education and is sponsored by the U.S. Department of Education. The resultant search yielded eight records, of which five were peer-reviewed journal articles, two were duplicates from the COMPENDEX and Inspec database search, and one was a book. For this search, I also did not limit the key terms because I wanted to retain any results that would supplement the COMPENDEX and Inspec search.

Inclusion and Exclusion Criteria

I used specific inclusion and exclusion criteria to refine my search results such that they answer my research question. The first exclusion criterion was that all records had to be peer-reviewed journal articles. Limiting the search to peer-reviewed journal articles ensures that high-quality, significant, and original works were used for the analysis. Additionally, I only analyzed articles published in the English language for this report because of the limited resources of this project

and my language ability. Table III details which criteria were included or excluded as an introductory step in the refinement process before I read any articles.

TABLE III
INITIAL EXCLUSION CRITERIA AND REASONING

Inclusions	Exclusions
• All Country/Region publications • The Year of publication • The Publisher of the article	• Not a Peer-reviewed journal article • Articles not published in the English language • Does not connect perspective-taking (or closely related skill) to ethical development (or closely related concept)

Country/Region publication is an included criterion because the applicability of a perspective-taking framework inside of engineering ethics education ideally spans country borders and affects all engineering education systems. I also included the Year of publication and the Publisher of the article because I wanted to encompass all the published works that could apply to this search as it is the first systematized literature review at this intersection of ideas. To begin the first major refinement stage, I had a total of 31 articles to review.

The first refinement stage consisted of reading each article's title, abstract, and keywords. This process removed 18 articles. Many of these articles talked about ethics broadly with no connection to teaching perspective-taking. Other articles focused on specific case studies with ethical implications like privacy, advanced technologies, and sustainability practices while only mentioning other perspectives on those issues. The second stage of analysis involved reading the full text of each article. This process removed eight articles: one without an articulation of ethical development but rather a cultivation of ethics more generally, one measuring perspective-taking of engineers related to other experts and laypeople in risk management, one in a therapeutic context, and five that did not make a connection to perspective-taking in the ethical development process. Figure 1 details the refinement process described above using the PRISMA approach created by Moher et al. in [17].

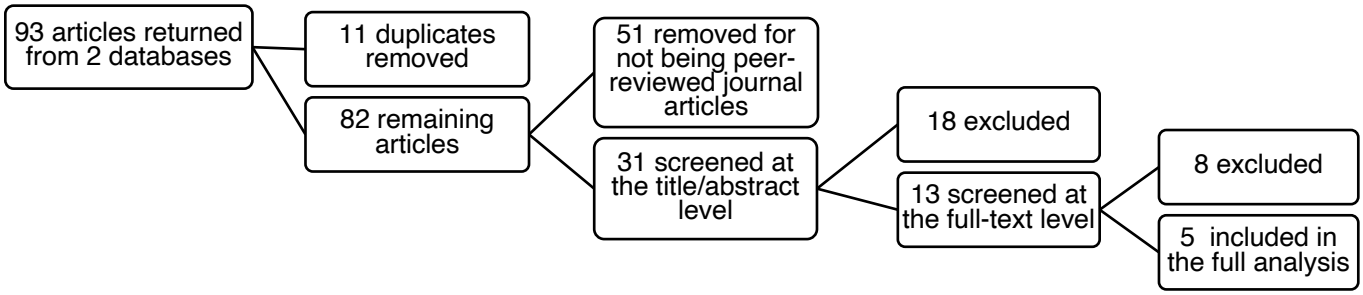

Fig. 1. Article Exclusion Process

Analysis

For the analysis of the five articles linking perspective-taking to ethical development, I classified each article by the framework, model, theory, or approach that was used or suggested. Additionally, I described the context in which the item was used or is intended to be used to

highlight its application. Specifically, I discussed how the perspective-taking models could be applied to the global, economic, environmental, and/or societal contexts called for in ABET Criterion 3.4. I also provided other comments regarding critiques of perspective-taking that were gathered during the analysis of the articles. I presented these to show the diversity of thought and the competing views for how to best educate undergraduate engineering students in ethics.

Results

The results discussed in this section represent four approaches to teaching perspective-taking across the five peer-reviewed journal articles that resulted from the review process executed above. The approaches are described in alphabetical order by article title to not place importance on one approach over another, and each approach is presented independently to preserve the context in which it was used or is intended to be used. This order, article details, and brief comments are included in the Appendix. Each approach uniquely implements perspective-taking, but they share a commonality in their emphasis on the importance of others' perspectives and lived experiences. This overarching theme places importance on others' perspectives and lived experiences and connects the approaches, but they also have distinct differences. The differences and commonalities will be discussed with references to how these could inform the global, economic, environmental, and/or societal contexts. Table IV presents the contexts that each approach addresses followed by a detailed description of the five approaches with specific references to how they incorporate perspective-taking.

TABLE IV
APPROACHES AND THE CONTEXTS THAT THEY ADDRESS

Proposed Framework/Model/ Theory/Approach	Population	Context(s) e.g., global, economic, environmental, and societal
Multi-dimensional analytical framework	Undergraduate	global, economic, societal
Reflexive principlism / SIRA	Graduate	global, economic, environmental, societal
Structured controversies	Undergraduate	global, economic, environmental, societal
Dimension of care	K-12	global, economic, societal

Multi-dimensional Analytical Framework

Jones [18] presents a revised framework for teaching computer ethics to undergraduate students in the context of information and communication technologies which I summarize as the multi-dimensional analytical framework. This framework uses ethical analysis that incorporates interdisciplinary perspectives in [18, p. 33] "that take into account the social and economic context…" of problems. The framework is described in six stages,

1. Identify a particular ethical dilemma.
2. Analyze the specific technologies involved and the social context of their design, deployment, and use.
3. Identify the values and principles that are at stake; gain a critical understanding of the "big picture" context.
4. Consider any applicable legal or regulatory frameworks.

5. Follow through with the previous three stages into professional practice.
6. Assess and evaluate potential solutions and practical courses of action.

Jones in [18, p.44] argues that "[t]his approach enables students to demonstrate that they have thought through an issue and arrived at a balanced conclusion by considering different arguments and perspectives." Jones makes it clear that taking up other perspectives is critical to the design, deployment, and use of computer systems and that a conclusion that does not consider those aspects cannot be balanced. For example, there are various environmental impacts and sustainability concerns associated with information and communication technologies that Jones mentions. These include finite raw materials, energy consumption coming from nonrenewable resources, toxic substance waste, and an "obsolete" mentality associated with older technological devices. The multi-dimensional analytical framework presents steps that can help remedy these impacts and concerns. Jones also connects the consideration of impacts and concerns to ethics:

> Ethical considerations can and should be embedded in projects from the outset, from the planning and design stages, right through the development life cycle, to implementation and evaluation. Key actors, users and stakeholders can, and should, be involved in the design of systems and devices from the earliest stages [18, p. 45].

Considering key actors, stakeholders, and their perspectives is not restricted to computer system creation. Although Jones does not mention other disciplines, I will describe how this framework could be used inside other moral/ethical contexts in the Discussion.

Reflexive Principlism within the SIRA Framework

One approach already implemented in the graduate engineering classroom explicitly combines perspective-taking with reflexive principlism within a structured learning framework: scaffolded, interactive, and reflective analysis, or SIRA [19]. Reflexive principlism in [20] is an ethical reasoning approach that asks the decision-maker to account for the four ethical principles of beneficence, nonmaleficence, autonomy, and justice to a particular ethical issue. Mentioned in two of the five analyzed articles, both from the same first author, this theoretical framework highlights perspective-taking as an independent stage of the ethical reasoning process. This process is broken into six stages: (1) Establishing knowledge, (2) **Perspective-taking** (bolding added)**,** (3) Compare and contrast, (4) Inducing conflict, (5) Decision making and justification, and (6) Meta-reflection [19]. One of the distinguishing factors of this approach is that the integration of reflexive principlism and the SIRA framework creates space for considering the perspectives of diverse stakeholders who may be directly or indirectly affected by the engineering decision that is made [19].

The two articles on reflexive principlism and the SIRA framework investigated the effectiveness of this approach from a qualitative [20] and a quantitative [19] lens. The qualitative lens gave insight into what aspects of the SIRA framework students reported as specifically impacting their perspective-taking tendencies. On the other hand, the quantitative lens used three instruments to measure changes in engineering students' ethical reasoning and empathic tendencies across the initial learning module and four cases studies which were all situated in the SIRA framework. The qualitative study found in [20, p. 547] that in projection or role-playing exercises "students were primed to think from stakeholder perspectives." Particularly, "[s]tudents reported a

heightened sense of open-mindedness and willingness to incorporate others' perspectives into their ethical decision-making process" [20, p. 549]. The qualitative study was shortly followed by the quantitative study to better ascertain whether there are measurable increases in students' ethical reasoning and empathic perspective-taking with the SIRA framework [19]. The results of the quantitative analysis were varied; the Engineering Ethical Reasoning Instrument (EERI) findings support the theoretical framework showing a significant increase in graduate student empathic perspective-taking and ethical reasoning, the Defining Issues Test 2 (DIT2) findings did not indicate change, and the Interpersonal Reactivity Index (IRI) measure indicated perspective-taking tendencies were enhanced [19]. Combining the results of these two studies, the qualitative and quantitative findings seem to suggest that there is tentative support for a framework that makes explicit the role of perspective-taking in engineering students' ethical development.

Structured Controversies

The structured controversies approach was introduced to undergraduate engineering students as an extension of role-playing in which facts and false information are used to bring up ethics conversations. The authors say in [21, p. 653] that "[a] structured controversy is a mode of teaching where the students are involved in role-playing and assume the identity of stakeholders brought together to debate an issue." Structured controversies can be made about any number of contentious topics such as economic, environmental, or legal concerns, so instructors can create a lesson around an issue pertinent to their local community or region. This flexibility also includes the ability to infuse false facts into the packet of information that students use when assuming the identity of the role they will play. By including false facts that students go on to tell as truth during the debate, the structured controversy is built in a way to facilitate discussions of ethical dilemmas that might arise during decision-making processes when using falsified or not wholly accurate information. Wareham et al. use this approach in their article with a class of civil engineering students to debate a potential development in an environmentally sensitive area [21]. Anecdotally, the authors state in [21, p. 656] that "students are quite imaginative in presenting possible arguments representing their stakeholder's viewpoint and, by and large, do a successful job of assuming the stakeholder identity." Although the article is limited to this environmental case, and the authors do not list examples of other cases that could be used, the viability of this approach lies in its flexibility and individualization.

Structured Controversies also emphasize the importance that each voice holds in the discussion and the reality that each perspective builds from a specific viewpoint or "ethical platform" [21]. The authors detail these perspectives as the utilitarian, teleological, and deontological viewpoints. These viewpoints are assumed by different role-players given their relationship to the controversy, and these viewpoints must be considered as part of the person's perspective when engaging in conversation. In particular, impasses are usually formed not only because participants stand on different ethical platforms but also because the participants have failed to understand others' ethical platforms [21]. Although less systematized than the SIRA framework, structured controversies offer opportunities for instructors to incorporate perspective-taking into their ethics content.

Dimension of Care

The dimension of care offers a feminist approach to engineering design that centralizes the perspectives of those affected by the design as well as considers the social and political dimensions commonly neglected in traditional framings of engineering design [22]. Written in the context of K-12 education, this article is a critique of the Next Generation Science Standards (NGSS) and the *Framework for K-12 Science Education* (*Framework*) and illustrates a potential way to address engineering design and decision-making concerns. Importantly, the authors argue in [22, p. 949] that "students need to be prepared to conceive of engineering design challenges as a complex intersection of sociocultural, material, biological, political, economic, [and] historical contexts…" Many of these contexts are shared in ABET Criterion 3.4; however, Gunckel and Tolbert advocate for other means to address these problems than a focus on ethics education. This position offers a unique argument against ethics education that the other articles do not provide, but the theme of perspective-taking still runs throughout the dimension of care.

The dimension of care caution that emphasizing ethics exclusively could lead to unintended outcomes. Instead, the authors propose a wider view of socio-political dilemmas to best capture the breadth of context in decision-making. The authors believe that current ethics interventions do not account for the dimensions of power and oppression that influence decision-making but that developing "social empathy is key to helping students understand and deconstruct contexts of power and inequality in classrooms, in the workplace, in the engineering design context, and in relationships between engineering and society" [22, p. 952]. The dimension of care differs strongly from the previous approaches because of its separation from ethics education, but the caring mindset could even be woven into the Structured Controversy. The dimension of care also creates a separation from traditional ethics education with its emphasis on emotion when engaging in ill-defined and context-dependent problems rather than following guidelines or principles [22]. The authors provide an example lesson for high school students where they develop solar cookers to replace nonrenewable fuel use. Where the NGSS and *Framework* focus on cost, use, and availability of materials in relation to access concerns, the dimension of care instead highlights the "sociopolitical issues that led to decreasing supply and/or inequitable access" [22, p. 954]. Combined with theoretical understandings of perspective-taking, the dimension of care could provide a transformative angle to engineering ethics education.

Discussion

The research question for this manuscript asked how perspective-taking is taught inside and outside the classroom to increase the ethical development of engineering students, and the Results section details how four approaches were or are intended to be used and their context. These four approaches highlight that there are opportunities for engineering instructors to incorporate perspective-taking into their ethics education content to work towards ABET Criterion 3.4 while maintaining the autonomy to implement approaches that work with their circumstances and preferences. Spanning 14 years, these articles speak to the short timeframe being investigated for links between perspective-taking and engineering students' ethical development. It should be noted that my search was not comprehensive and that a more exhaustive search could show attempts in engineering or other professional fields to relate ethics and perspective-taking. Decisions are made every step of the way from ideation to design to implementation to evaluation during the life cycle of an engineering solution. Therefore,

perspective-taking skills must be used to capture the ethical dimensions of engineering solutions and their impacts. Engineers work at the intersection of societal, economic, environmental, and global contexts as they work towards overcoming challenges. Hess et al. take the next step arguing:

> The development of empathic perspective-taking should enable engineering students to accurately identify, understand, and (ideally) care about the views and needs of stakeholders impacted by engineering decisions. … [Perspective-taking] enables engineers to consider the needs and values of numerous stakeholders with whom they may never directly interact, but who will be affected by the use and impact, including the unintended use and consequences, of their solutions [20, p. 535].

This quality of attempting to understand and value the diverse perspectives of stakeholders is aligned with ABET Criterion 3.4 learning outcomes and speaks to the applicability of perspective-taking approaches to ethics education.

These four approaches offer valuable content for engineering educators to consider, but work has been done in other fields related to perspective-taking and ethical development that could provide more support for their implementation. As mentioned in the Literature Review, Kahn and Zeidler's Socioscientific Perspective Taking (SSPT) model in [6] and Garrigan et al.'s Social Information Processing-Moral Decision-Making (SIP-MDM) framework in [8] could provide additional support for perspective-taking not currently available in the engineering literature. The SSPT model includes a "moral context" made up of reflective and reflexive judgment. This moral context could be used to situate a societal, economic, environmental, or global context relevant to the students and ethics content for an instructor.

The SIP-MDM framework is a comprehensive framework with perspective-taking included in a "database." The database interacts individually with emotion processes, social factors, and brain development and is enclosed in a six-step, multidirectional process: (1) encoding cues, (2) interpretation of cues, (3) clarification of goals, (4) response access or construction, (5) moral response decision, and (6) behavior enactment [8]. This framework could provide a more robust theoretical foundation for perspective-taking content to build from in the engineering classroom as well as continue to aspire to ABET Criterion 3.4. Notably, both SSPT and SIP-MDM help close the gap in current ethics education methods by situating the ethical decision-making process inside the larger context of the experience or event. Using SSPT or SIP-MDM as a foundation to inform how the above four approaches can be used would help engineering educators be intentional about the ethics education they use in their classroom as well as help create engaging, meaningful, relevant, and informative content for their students.

Limitations

There are three distinct limitations to this study: population of each study, a limited amount of research, and counterarguments to perspective-taking. First, the four approaches target K-12 (dimension of care), undergraduate (multi-dimensional analytical framework, structured controversies), and graduate (reflexive principlism / SIRA) students. This spread of student population being studied means that translating results of the dimension of care or reflexive

principlism / SIRA to undergraduate engineering students may be difficult and/or may not be effective. Hess et al. make specific note that their study was conducted in a graduate-level course and that translating these findings to the undergraduate level may pose challenges [20]. Although each approach examined in this study specified one population, future research into the open question of applying these approaches across different populations could give further insight into their effectiveness.

Second, the limited amount of research at the intersection of perspective-taking and ethical development in engineering students should not be understated. I caution that the amount and quality of evidence from each article presented in this report vary, and the variation should be considered if this intersection were investigated further. Evaluating only four approaches leaves much to be desired in terms of breadth and variety, but I believe there is room for this research area to grow, and implementing these approaches could prove valuable. Instructors may feel like they are limited in the number of options they have when trying to implement perspective-taking into their ethics content if only these four approaches are given. However, these approaches are open to alterations or context-specific content design although it requires more work for the instructor.

Lastly, Hess et al. offer a compelling argument against solely focusing on perspective-taking: "the needs of stakeholders may conflict, and thereby perspective-taking alone is often insufficient for arriving at a just or morally defensible solution" [20, p. 537]. Gunckle and Tolbert have a similar quote from the *Framework for K-12 Science Education* that says that "one person's view of the optimal solution may differ from another" [22, p. 946]. In combination, these three limitations prevent any sweeping recommendations to be made about pedagogy or methods for the time being.

Conclusions

From this systematized literature review, it is evident that scholars have recently been investigating the connection between perspective-taking and students' ethical development. From the original 93 records, 31 articles were initially examined, and five articles produced four approaches connecting perspective-taking and ethical development. Although perspective-taking is a "fuzzy" [6, p. 9] concept and the boundaries continue to be defined and its definition refined, it may serve as a valuable mechanism by which to meet ABET Criterion 3.4. Students would also likely benefit from considering and taking up the perspective of various stakeholders in environmental and economic challenges, especially those related to sustainable design and advanced technologies. Perspective-taking could also provide utility in communication and coordination contexts which fall inside many engineering projects. As these domains mature, it will be critical for engineers to have a deep understanding of the consequences of their decisions, and the perspectives of those who are affected would likely provide invaluable context. Future research should consider how the current perspective-taking approaches identified in this report (multi-dimensional analytical framework, reflexive principlism / SIRA, structured controversies, dimension of care) can be combined with theoretical understandings of perspective-taking (Socioscientific Perspective Taking, Social Information Processing-Moral Decision-Making) to create a more comprehensive implementation strategy for teaching perspective-taking in the classroom as a means of promoting students' ethical development. I recommend taking these

findings as a starting point for intentionally implementing the perspective of others into engineering ethics education content to produce the most honest, impartial, fair, and equitable answers and solutions to the world's global, economic, environmental, and societal concerns. Educating in this manner could contribute to the basis for engineering students to make sound judgments that may run contrary to outside influences and pressures such as profit, time, and energy.

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I would like to thank all my Reviewers. Thank you for taking the time to help me improve my report.

Appendix – Reviewed Articles

TABLE 5
SUMMARY OF REVIEWED ARTICLES

Title	Author(s)	Date	Proposed Framework/Model/ Theory/Approach	Population
Doing the right thing: computer ethics pedagogy revisited	Jones	2016	Multi-dimensional analytical framework	Undergraduate
Enhancing engineering students' ethical reasoning: Situating reflexive principlism within the SIRA framework	Hess et al.	2019	Reflexive principlism / SIRA	Graduate
Introducing Ethics Using Structured Controversies	Wareham et al.	2006	Structured Controversies	Undergraduate
The Development of Empathic Perspective-Taking in an Engineering Ethics Course	Hess et al.	2017	Reflexive principlism / SIRA	Graduate
The imperative to move toward a dimension of care in engineering education	Gunckel & Tolbert	2018	Dimension of Care	K-12

References

[1] National Society of Professional Engineers, "NSPE ethics reference guide." Sep. 2021. Accessed: Nov. 23, 2021. [Online]. Available: https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/EthicsReferenceGuide.pdf

[2] American Society for Engineering Education, "ASEE code of ethics for engineering educators." Jun. 16, 2019. Accessed: Nov. 23, 2021. [Online]. Available: https://aseecmsduq.blob.core.windows.net/aseecmsdev/asee/media/content/member%20resources/pdfs/engineeringeducatorscodeofethics.pdf

[3] Institute of Electrical and Electronics Engineers, "IEEE code of ethics." Jun. 2020. Accessed: Nov. 23, 2021. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html

[4] B. E. Barry and M. W. Ohland, "ABET criterion 3.f: How much curriculum content is enough?," *Sci Eng Ethics*, vol. 18, no. 2, pp. 369–392, Jun. 2012, doi: 10.1007/s11948-011-9255-5.

[5] Accreditation Board for Engineering and Technology, Inc., "ABET criteria for accrediting engineering programs, 2021 – 2022." Oct. 31, 2020. Accessed: Oct. 15, 2021. [Online]. Available: https://www.abet.org/wp-content/uploads/2021/02/E001-21-22-EAC-Criteria.pdf

[6] S. Kahn and D. L. Zeidler, "A conceptual analysis of perspective taking in support of socioscientific reasoning," *Sci & Educ*, vol. 28, no. 6–7, pp. 605–638, Sep. 2019, doi: 10.1007/s11191-019-00044-2.

[7] T. D. Sadler, S. A. Barab, and B. Scott, "What do students gain by engaging in socioscientific inquiry?," *Res Sci Educ*, vol. 37, no. 4, pp. 371–391, Oct. 2007, doi: 10.1007/s11165-006-9030-9.

[8] B. Garrigan, A. L. R. Adlam, and P. E. Langdon, "Moral decision-making and moral development: Toward an integrative framework," *Developmental Review*, vol. 49, pp. 80–100, Sep. 2018, doi: 10.1016/j.dr.2018.06.001.

[9] American Psychological Association, "Perspective taking," *APA dictionary of psychology*. 2021. Accessed: Sep. 21, 2021. [Online]. Available: https://dictionary.apa.org/perspective-taking

[10] J. L. Hess and G. Fore, "A systematic literature review of US engineering ethics interventions," *Sci Eng Ethics*, vol. 24, pp. 551–583, Apr. 2018, doi: 10.1007/s11948-017-9910-6.

[11] K. D. Stephan, "A survey of ethics-related instruction in U.S. engineering programs," *Journal of Engineering Education*, vol. 88, no. 4, pp. 459–464, Oct. 1999, doi: 10.1002/j.2168-9830.1999.tb00474.x.

[12] A. R. Todd and A. D. Galinsky, "Perspective-taking as a strategy for improving intergroup relations: Evidence, mechanisms, and qualifications," *Social and Personality Psychology Compass*, vol. 8, no. 7, pp. 374–387, Jul. 2014, doi: 10.1111/spc3.12116.

[13] M. J. Grant and A. Booth, "A typology of reviews: an analysis of 14 review types and associated methodologies: A typology of reviews, *Maria J. Grant & Andrew Booth*," *Health Information & Libraries Journal*, vol. 26, no. 2, pp. 91–108, Jun. 2009, doi: 10.1111/j.1471-1842.2009.00848.x.

[14] W. Zakharov, "Creating a Boolean search string [Class handout]." Purdue University, ENE 503, Sept. 2021.

[15] Elsevier, "Ei Compendex: Most complete engineering database," *Ei Compendex: Most complete engineering database*, 2021. https://www.elsevier.com/solutions/engineering-village/content/compendex (accessed Nov. 23, 2021).

[16] Elsevier, "Inspec: Engineering research database," *Inspec: Engineering Research Database*, 2021. https://www.elsevier.com/solutions/engineering-village/content/inspec (accessed Nov. 23, 2021).

[17] D. Moher, A. Liberati, J. Tetzlaff, D. G. Altman, and for the PRISMA Group, "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement," *BMJ*, vol. 339, no. jul21 1, pp. b2535–b2535, Jul. 2009, doi: 10.1136/bmj.b2535.

[18] S. Jones, "Doing the right thing: Computer ethics pedagogy revisited," *Journal of Information, Communication and Ethics in Society*, vol. 14, no. 1, pp. 33–48, Mar. 2016, doi: 10.1108/JICES-07-2014-0033.

[19] J. L. Hess, J. Beever, C. B. Zoltowski, L. Kisselburgh, and A. O. Brightman, "Enhancing engineering students' ethical reasoning: Situating reflexive principlism within the SIRA

framework," *Journal of Engineering Education*, vol. 108, no. 1, pp. 82–102, Jan. 2019, doi: 10.1002/jee.20249.

[20] J. L. Hess, J. Strobel, and A. O. Brightman, "The development of empathic perspective-taking in an engineering ethics course," *Journal of Engineering Education*, vol. 106, no. 4, pp. 534–563, Oct. 2017, doi: 10.1002/jee.20175.

[21] D. G. Wareham, T. P. Elefsiniotis, and D. G. Elms, "Introducing ethics using structured controversies," *European Journal of Engineering Education*, vol. 31, no. 6, pp. 651–660, Dec. 2006, doi: 10.1080/03043790600911712

[22] K. L. Gunckel and S. Tolbert, "The imperative to move toward a dimension of care in engineering education," *Journal of Research in Science Teaching*, vol. 55, no. 7, pp. 938–961, Sept. 2018, doi: 10.1002/tea.21458.