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Chapter 32

The Role of Inclusion, Diversity, Equity, and Access (IDEA) in Agricultural and Biological Engineering

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The Role of Inclusion, Diversity, Equity, and Access (IDEA) in Agricultural and Biological Engineering

Deepak Keshwani, Jennifer Keshwani and Marybeth Lima

Introduction

The goal of this chapter is to explore the importance of inclusion, diversity, equity, and accessibility (IDEA) in agricultural and biological engineering education and how IDEA principles can be integrated in our educational efforts. We want to acknowledge that the ideas and suggestions presented in this chapter are situated in a North American context. We are equal contributors to this chapter; thus, the order of authors is alphabetical.

What Is IDEA?

As a starting point, we would like to discuss definitions and context of the various words in the IDEA acronym. Lima and Keshwani (2022) in their definitions state the importance of inclusion in our current social context and note its importance for engineering because there are groups who have been on the margins whose needs have not been met in design practices. Zallio and Clarkson (2021), who reviewed IDEA in the design of the built environment, state: "When it comes to definitions, it is helpful to underline that accessibility is about designing and building a solution usable by as many people as possible. Diversity is about guaranteeing that everybody is recognised as a unique human being: it's about empowering people by respecting and appreciating what makes them different, in terms of age, gender, ethnicity, religion, disability, sexual orientation, education, and national origin. Equality is about ensuring everybody has an equal opportunity and is not treated differently or discriminated against because of their characteristics. Equity is about ensuring that everyone has access to the same opportunities. Inclusion concerns the opportunities that everyone should use the same facilities, take part in the same activities, and enjoy the same experiences, including people who have a disability or other disadvantage". Chugh (2018), in her insightful book entitled *The Person You Mean to Be: How Good People Fight Bias*, writes about how diversity is about gateways (getting people in), and how inclusion is about pathways (getting people through). Each of these definitions has useful dimensions in connection to engineering design and practice.

We were unable to find literature involving IDEA in agricultural and biological engineering (ABE), other than the recent piece in *Resource Magazine* (Lima & Keshwani, 2022). Though there is literature involving IDEA in engineering and engineering design (Clarkson et al., 2003; Smith-Doerr et al., 2017; *U.S. Access Board – U.S. Access Board – Home*, n.d.; Walden et al., 2018), there is a dearth of literature with respect to consideration of these factors simultaneously. Two areas of engineering and design that apply IDEA concepts include the digital environment and the built environment. With respect to the former, Microsoft has an extensive online resource with regard to the digital environment here: https://www.microsoft.com/design/inclusive/.

Regarding built environment, (Zallio & Clarkson, 2021) reviewed the use of IDEA in civil engineering and architectural design as related to assessment tools "to highlight the state of the art of assessment tools that consider inclusion, diversity, equity and accessibility (IDEA) with a people-first approach". They found that design work for the built environment focused more on accessibility than the other three areas; that the number of published articles centred on these considerations has increased, especially after 2015; and that holistic, mixed-method assessment tools have "the potential to guarantee accessible, equitable, diverse and inclusive spaces for everyone". These authors also state that "inclusion has the potential to become a form of sustainability as a proclamation about equity and diversity".

We believe that long-standing priorities in ABE, including systems thinking, sustainability, and a focus on people, make members of our discipline particularly well-suited to integrating IDEA into engineering education and practice.

We also recognise that there is an inherently personal dimension to this work, and that at times it can feel uncomfortable, perhaps from a lack of background (most of us have no formal education in these topics), because it feels incompatible or at odds with our training, because it can lead to difficult conversations and personal truths, or for other reasons. Because of this, we share parts of our personal stories with respect to IDEA in ABE in the hopes that readers will better understand and feel more comfortable "taking the plunge" in navigating this dimension of IDEA practice in engineering.

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Deepak's story: *In my first year teaching a capstone design course, I developed a reflective assignment where students had to describe global, cultural, and social factors relevant to their design project and associated ethical issues that they should consider. If a factor was not relevant to their design project, students had to justify it. A student in the class approached me about the assignment and felt that their project didn't need to consider any global, cultural, or social factors since their team was designing a specific diagnostic process and tool for use by healthcare providers and their patients. After a rather lengthy discussion, we brainstormed how there could be a myriad of relevant factors including patient demographics, language, accessibility, etc., and how those could prompt some ethical issues. I also intentionally discussed the Accreditation Board for Engineering and Technology (ABET) outcomes related to design and ethics that highlight the importance of careful consideration of social aspects in design. One comment from the student stood out to me. He said that if it was so important, how come this is the first time they've been asked to do this in an engineering course. That comment was really convicting. It made me realise just how much our curriculum perpetuates the technological-social divide in engineering. I found myself wondering if my assignment was even useful as an assessment tool if we are not equipping students to engage with the social context.*

Jenny's story: *Monitoring teamwork in a college engineering classroom is not a passive task. One semester, as I wandered my classroom of sophomore engineering students, my attention fell on one team. Three students. Two agricultural engineering majors and one biological engineering major. Two male. One female. Two white. One Asian American. I was sad, but not surprised, to notice the one female, Asian American, biological engineering student was being completely shut out of the conversation by her two male, white, agricultural engineering major teammates.* Despite all my reminders in class that we are a community, we learn best from each other, we each have strengths and talents to offer, and including others is just the right thing to do; her thoughts, ideas, and abilities were ignored. *As any intentional professor would do, I asked the two white, male, agricultural engineering students to schedule a meeting with me in my office. Which they did. They politely came and listened to me explain the interactions I had observed and why this is unacceptable in our classroom. They explained they were just reserved and more comfortable talking with each other. I assured them I would be watching their team interactions in the future. I did not witness these two students ignore a teammate during the remaining few weeks of the semester. However, I'm not convinced their underlying motivations were impacted by the experience.*

Marybeth's story: *I've plunged increasingly further into IDEA concepts in design by working with communities (often elementary schools) to design playgrounds that are specifically geared toward the community and that place children at the centre of the design process* (Lima, 2013, 2014). *In this context, I was working with a school to replace a pre-kindergarten playground; their current playground consisted of a bucketball, a small geodesic dome climber, and a rusty red gate that my students and I nicknamed "the gate to nowhere" (*Figure *32.1 a). We were motivated to upgrade the playground*

FIGURE 32.1 Playground that was the focus of Marybeth's community-based design project.

because the 60 children who played on it had almost nothing to do. They could look through a chain link fence (topped with barbed wire) at a backyard playground that had a tree house, swings, slides, and climbers. We had been collaborating with the school for six months when I asked the principal about the story behind the gate: how did it come to be there? She told me that it had been the entrance to some old play equipment that had to be removed for safety reasons, but whoever had removed the equipment had left the gate behind. "It's the kids' favourite piece of equipment on the playground", she then said. When she saw my shock, she said, "During recess, the teachers line up the kids in front of that gate. They ask the children, 'Where do you want to go today, anywhere in the universe?' Once the child in line has thought of a location, they run through the gate, and yell the location as they do. They take turns and it's their favourite thing to do". What my students and I had nicknamed the gate to nowhere was actually the portal to anywhere.

Even while paying attention to inclusive design and systems thinking, my students and I made so many mistakes in this situation. Our stakeholder analysis and teamwork efforts had not uncovered critical information about the role of the portal; we made bad assumptions that minimised the perspective of the community with whom we were collaborating. For me, this moment was a wakeup call, to remember to ask the right questions at the outset; expressing the soul of the community is critical in community-based design, and in this case, we almost missed it. While we eventually added a new playground *and kept the portal (*Figure *32.1b), the thorny boundary that separates the school from the surrounding community, and that reinforces the "keep out" message to the children, is still there. Designing with IDEA in mind is a journey and an evolution, and I am still actively learning and practising these principles today.*

Engineering Connections to IDEA

Engineering is inherently a service profession with an explicit commitment to improve the human condition for all people and the broader ecosystems with which people interact. Agricultural and biological engineers apply their engineering skills to solve problems related to food, energy, water, agriculture, and related systems. The work we do and the engineering innovations we design directly impact people every day. We need look no further than the preamble of the National Society of Professional Engineers code of ethics to remind ourselves of that commitment (*Code of Ethics | National Society of Professional Engineers*, n.d.). This commitment also shows up implicitly in ABET student outcomes that expect students to consider global, cultural, and social factors in their work as engineers (*Criteria for Accrediting Engineering Programs, 2022 – 2023 | ABET*, n.d.).

As educators, we are tasked with preparing future agricultural and biological engineers for this commitment to improve the human condition for *all people and the broader ecosystems with which people interact.* Embedding IDEA principles intentionally and strategically into our curriculum is one potential strategy. When we think about IDEA in an engineering context, we may primarily associate it with efforts to attract a diverse group to the profession, with the assumption that diverse people will bring diverse perspectives and doing so will help enhance our profession. After all, research indicates that increased diversity is positively correlated with enhanced decision making (Rock & Grant, 2016), financial outperformance (*How Diversity, Equity, and Inclusion (DE&I) Matter | McKinsey*, n.d.), and increased innovation (Phillips, 2014).

While we need to continue our efforts to increase diversity to enhance our profession, we contend that it is not enough. Increasing participation of engineers from diverse backgrounds places the burden of change on the underrepresented groups entering our profession. We believe that embedding IDEA concepts into the practice of engineering helps make this our collective responsibility and that requires intentional integration of IDEA into engineering curricula.

Previously, the authors introduced an inquiry-based framework that imbeds IDEA into the engineering design process (Lima & Keshwani, 2022). In this chapter, we will revisit that framework, explore the necessary knowledge, skills, and abilities that engineers need to develop to utilise the IDEA framework in practice, and discuss curricular implications and resources.

IDEA Framework for Design

A framework for IDEA-informed design was shared in the American Society of Agricultural and Biological Engineers (ASABE) publication, *Resource Magazine* (Lima & Keshwani, 2022). The framework describes specific considerations during the design process that should be addressed to ensure designs and the design process are inclusive, represent diverse perspectives, and are equitable and accessible to all. IDEA principles must be considered with respect to the people who participate in the design process and will be impacted by the people who participate in the design process, as well as the design process itself, the designed artefact, and within the broader context in which we design (see Figure 32.2). A salient feature of this framework is that it fosters an inquiry-based approach that intentionally bridges the technological and social aspects of practising engineering design.

The framework originated after discussions at the 2022 Annual International Meeting of ASABE at two sessions focused on IDEA. During both sessions, it became apparent that there was a gap between our engineering and engineering education practices, and the principles of IDEA. However, this also presented an opportunity for us to adopt a systems perspective when it comes to engineering design. This is a living framework that will and should continue to evolve and we welcome readers' feedback and suggestions to enhance it.

Essential Elements to Support the Framework

Preparing engineering students with the knowledge, skills, and abilities to create inclusive designs is crucial and requires understanding the diverse needs and perspectives of all users. By learning how to design with inclusivity in mind, we can create products and systems that are accessible and beneficial to a wider range of individuals. In this section, we will describe various avenues and strategies for equipping engineering students to implement the IDEA design principles.

Systems Thinking

Systems thinking skills provide the necessary tools to understand, create, and influence systems of interconnected sets of elements coherently organised to achieve something. (Meadows, 2008). Equipping ABE students with systems-thinking skills is not only vital for their professional goals, but also provides the awareness and skill to navigate complex IDEA challenges in their personal and professional lives. Developing systems thinking is crucial for the success of any engineering project. Systems thinking is the ability to understand complex interconnections between different components of a system and how they interact and affect one another. Through this ability, engineers can identify potential weaknesses and strengths of a system, allowing better decisions when designing and constructing a project. Systems thinking also helps engineers develop an understanding of how a system can be improved, and how to make it more efficient and cost effective. Systems thinking is an important skill for future engineers to possess, as it enables them to design and construct more efficient and reliable systems that meet the needs of their communities. The skills and abilities we impart on our students may feel small, but small things add up to create bigger, societal impacts, as reflected in a core principle of emergent strategy and broader systems thinking (Brown, 2017).

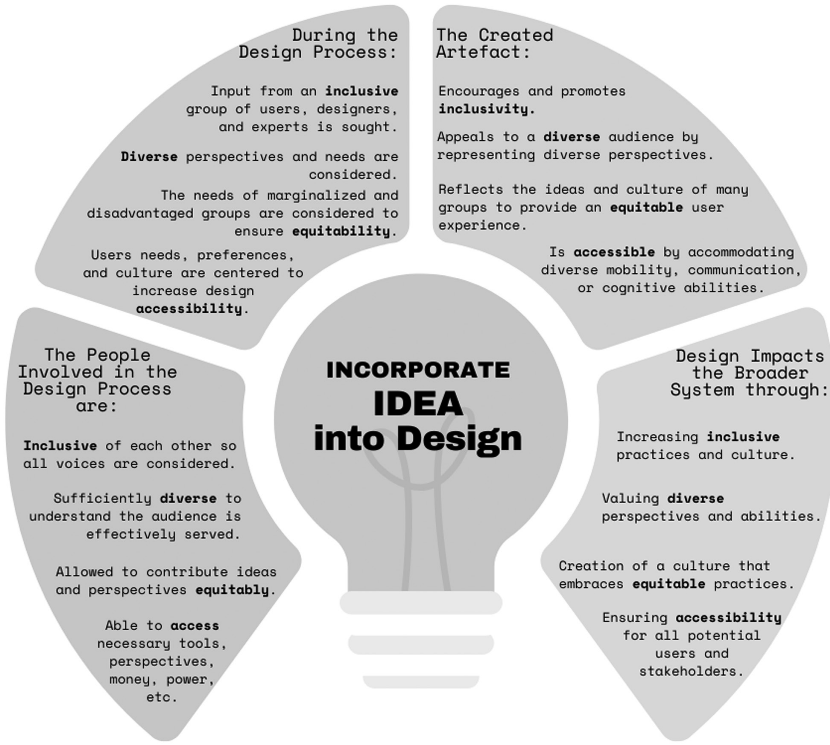

FIGURE 32.2 IDEA Framework for Design (Source: authors' compilation adapted from Lima and Keshwani (2022)).

ABE students and professionals are always working within systems. Corn fields, the human body, and the food production chain are all examples of complex systems ABE works within. ABE programmes provide knowledge of individual components of relevant biological systems through advanced courses in biology, agronomy, and engineering sciences to equip ABE students. However, to prepare students to address core problems instead of simply symptoms of those problems, future engineers must be empowered to view, analyse, and manipulate systems. Systems thinking provides the tools to assess current systems and identify leverage points to alter systems to achieve the desired outcomes. Waters Center for Systems Thinking has identified 14 Habits of a Systems Thinker (Waters Center for Systems Thinking, 2020).

The Habits of a Systems Thinker include aspects of conceptualising a system ("Makes meaningful connections within and between systems"), analysing systems ("Changes perspective to increase understanding"), and taking informed action ("Uses understanding of system to identify possible leverage actions"). Providing opportunities for students to develop these habits with respect to the ABE systems they will impact during their careers is vital. Systems-thinking habits also support student implementation of the four components of the IDEA framework for design, as detailed below.

System Inclusivity

An inclusive system will recognise that there are several groups in the margins whose needs may be overlooked during the design process. Using the systems-thinking habit of "change[ing] perspective to increase understanding" allows engineers to view a design from perspectives other than their own to give space for other voices to enter the design process (Waters Center for Systems Thinking, 2020). Ensuring design inclusivity requires identifying all participants in a system and then seeking feedback and perspectives from all participants.

Communication skills are a good first step to equip students to consider other's perspectives. The ability to interview stakeholders from diverse user groups and truly listen to responses enables engineers to consider many perspectives (Hess & Fila, 2016). Competence in changing perspectives also requires acknowledging personal mental models that frame individual experiences of the world. Spending time with students to work through the culture, beliefs, and attitudes they find "normal" is helpful preparation to provide space to consider alternative perspectives. Also, understanding the history of a system is helpful to identify how the current system function was designed and maintained. Acknowledging that our current cultural system is the result of all the cultures that came before us is a useful experience for students to learn to consider perspectives other than their own.

Value Diversity Within the System

As we highlighted in our personal stories, the habits and character our students develop serves as the foundation of their life-long practice as engineering professionals. The way our students treat their classmates impacts how our graduates value colleagues and supervisors. The perspectives our students consider in their senior design projects guide the ways they consider the user experience of their designs. Reflecting on

Jenny's story above, while the male students acted in response to Jenny's directions, they didn't think to enact a solution themselves – they needed to be prompted. While the students appeared to change the way they treated their classmates, Jenny was left with the thought that they complied out of external pressures (grades, respecting authority), rather than truly understanding the principle. The overall impact likely had not changed the safety of students of colour on my predominantly white campus (Suza, 2023). A system that values diversity will ensure that many perspectives participate in the design process and implementation. One relevant systems-thinking habit is considering "how mental models affect current reality and the future" (Waters Center for Systems Thinking, 2020). This is the ability to consider how the attitudes and beliefs of designers and users impact system function. Creating a diversity-sensitive design requires ABE professionals to acknowledge their personal mental models and seek to understand the mental models or those impacted by their designs.

Similarly, developing skills in perspective-taking equips students to consider how mental models affect current reality and the future. Starting with a baseline of understanding that my personal mental model may be different than others, this systems-thinking habit considers the impacts of different mental models on choices and design reception. Providing examples of designs that failed to fully consider the mental models of the user audiences can be helpful. For example, the development process for American Sign Language gloves (Erard, 2017) was overly dependent on the designer's mental models of how people who are deaf or hard of hearing would like to communicate with people who hear. Seeking to first understand user needs and attitudes toward the problem to be solved would have led the design team to a much different solution.

Improving System Equity

An equitable system will treat everyone fairly and without bias. A relevant systems-thinking habit is that ABE engineers should be able to "recognize that a system's structure generates its behaviour" (Waters Center for Systems Thinking, 2020). This awareness and ability to acknowledge that the systems we interact with daily have an intended function provides ABE engineers with opportunities to improve the equity of those systems. A historical understanding of society and how our culture developed helps equip students to recognise that a system's structure generates its behaviour. The systems we live in are not broken. They are behaving exactly as they were designed to function (Stroh, 2015). The problem is that the original designs were not equitable. While all engineering students participate in humanities courses (history, sociology) which provide a structure to assess the current structure of the systems within which we design, they receive little insight into how to use what they learn in humanities courses in an engineering context. It is incumbent upon engineering educators to make the connections between humanities and professional engineering explicit. This background structure empowers ABE professionals to create solutions that rise above the current limitations of inequitable systems. Additionally, critiquing examples of quick fixes that fail (Stroh, 2015) describes the short-term responses to mitigate systemic issues that lead to ongoing problems – sometimes even worsening problems – provides students skills in identifying when short-sighted solutions negatively impact system equity.

System Accessibility

An accessible system can be used, approached, or understood by everyone. A relevant systems-thinking habit for designing system accessibility is the ability to "consider short-term, long-term and unintended consequences of actions". Providing a short-term solution to a problem that does not consider the broader systemic issues may lead to limited accessibility to a design. For example, developing a cost-prohibitive solution to reducing agricultural water use may work in wealthier countries, but the design will not be feasible in communities with fewer resources to support agricultural technology.

Requiring students to include a discussion of consequences in design analysis is a good first step in equipping students to consider short-term, long-term, and unintended consequences of their designs (Cech, 2014; Lima & Oakes, 2014; Walsh et al., 2019). However, this method does not provide students with an opportunity to personally experience design consequences. Real-world, implementable design experiences through "service-learning" or community engagement exercises have potential to allow students to discover the consequences of their designs. Ensuring that the design experience does not end with the delivery of the design to the community, but instead continues through implementation and collection of user feedback, provides optimal learning opportunities for understanding the impact of short-term, long-term, and unintended consequences.

Engineering Ethics

In the introduction of the chapter, we alluded to the National Society of Professional Engineers Code of Ethics. In alignment with the existing literature base on engineering ethics education (Diduch et al., 2012; Hess et al., 2021; Rottmann & Reeve, 2020), we contend that there needs to be a stronger connection between engineering ethics and IDEA principles. Engineering ethics is one of the primary means to assess and regulate the impact of engineering decisions on the lives of people. Therefore, engineering ethics is crucial to realising IDEA principles.

Historically, both the practice of engineering ethics and the teaching of engineering ethics has used a Rules and Code approach based on contractual obligations. Given our tendency to prioritise technical knowledge over social considerations, this has led to a utilitarian approach to addressing ethical problems in engineering (Bowen, 2009). This tendency to prioritise technical knowledge over social considerations has been identified as one potential explanation for a historic decoupling of ethics and equity in engineering (Rottmann & Reeve, 2020). A contractual approach also implies that the motivation for ethical behaviour is based on social agreements that are enforced or managed by regulations (Bowen, 2009). This approach does then prompt a question about who was at the table when those social agreements and regulations were articulated (formally or informally). This consideration is particularly relevant to ABE, given the past homogeneity in the demographics of our profession and research that suggests that norms of dominant groups can restrict underrepresented voices and views, for example those of women engineers (Faulkner, 2000) or those who are not white (McGee & Martin, 2011). Currently, there is little research on the experiences of underrepresented voices in ABE. Two notable exceptions are studies examining the experiences of female faculty in ABE (Abadie et al., 2009; Cauble et al., 2000). As a profession, we are in the early stages of understanding our past and present as it relates to IDEA.

A common approach to teaching and professional development related to engineering ethics has been using case studies based on two dimensions: an inductive/deductive dimension and a micro/macro dimension, and often some combination of these (Rottmann & Reeve, 2020). An inductive approach will use a specific situation to identify ethical lessons. For example, what can we learn from examining a bridge collapse. A deductive approach establishes a specific moral framework or ethical concern, and then applies that to the analysis of an event, for example, application of care ethics to a specific medical technology, or asking how deciding to build a dam in a particular location leads to inequity in terms of benefits to various groups of people.

A micro approach typically involves an individual or group of engineers and their clients or employers, while a macro approach focuses on collective responsibility in a broader social and political context (Herkert, 2005). For example, a case study looking at the consequences of an employee not following standard machinery testing protocols would be a micro approach. An example of a macro approach would be examining long-term consequences of agricultural machinery automation on rural unemployment.

Case studies offer the opportunity to discuss ethical scenarios for practical situations that are often based on past events or likely-to-happen events. In an ABE context, some of the challenges include a lack of case studies that intentionally apply deductive strategies to situations and a lack of macro-level case studies. It is in the macro dimension where socio-political consequences and the broader impacts of engineering decisions can be explored. It is in these broader impacts that we often see systemic issues arising that impact IDEA. Case studies also need to balance negative behaviours with moral exemplars, and balance shock/disaster situations with more common everyday mundane situations.

From an implementation perspective, for case studies to be effective, they need to be accompanied by an ethical theory or framework that can be applied in a situation for the learning to be internalised and transferable to other situations. There is a range of theories that can be applied in an ABE context. Some examples include virtue ethics (Hooft, 2014), moral foundations theory (Graham et al., 2013), and ethics of care (Held, 2006).

Another barrier to connecting ethics to IDEA is the compartmentalisation of ethics within a specific-time point (i.e. senior design or a senior seminar course) and lack of disciplinary context if taught broadly for multiple majors. The limited research on engineering ethics in the context of ABE that has been done has already recommended as best practice integration across the curriculum and specificity to disciplinary contexts (Rottmann & Reeve, 2020).

A final consideration is curricular flexibility for non-technical course content. Ethical decision making in an engineering context that integrates IDEA principles requires our students to be comfortable discussing and evaluating social and cultural contexts. How do we equip students in this regard? One approach is to lean into the teaching expertise at our institutions from humanities, arts, and social sciences through required general education courses, and build on that initial exposure by intentionally integrating social and cultural contexts into our disciplinary courses throughout the curriculum. Doing so will normalise social considerations in engineering and will counter the over-reliance on the utilitarian approach to engineering ethics.

Stakeholder Analysis

Embedding IDEA principles into engineering practice and design in particular requires an intentional consideration of the impacts of engineering decisions and solutions on people. Stakeholder analysis is one strategy that can be used to centre our engineering practice around people. This approach is often used in project management to effectively assess project requirements and engage with individuals on resource management, decision making, and communication (PMI, 2013). Design-thinking also utilises a stakeholder analysis framework as a means to evaluate desirable product features and develop empathy for the end-users (Köppen & Meinel, 2015; Plank et al., 2021).

We define stakeholders as any individual or group of individuals involved, influenced, or impacted by the design process. Stakeholders would include individuals directly involved with the engineering design process, such as the engineers, employers, clients, but also those not directly involved, such as potential end-users of a product or process, suppliers of resources that might be needed, individuals or groups that might be in proximity (spatially or temporally) to an implemented solution, regulators, policy makers, etc. Embedding stakeholder analysis early in the engineering design process has merit, as it may help identify potential criteria and constraints beyond obvious functional attributes of a design. In the context of IDEA, stakeholder analysis can be used to identify those whose voices and perspectives are hidden or could be diminished in the design process.

We propose a four-step stakeholder analysis that can be summarised as follows:

- **Step 1:** Team-based brainstorming to identify the broadest possible set of stakeholders and clearly define their interest on the outcome from the engineering design process.
- **Step 2:** The team then categorises their interest on a qualitative scale as high, medium, or low.
- **Step 3:** For each stakeholder, the team then defines their influence over the process as high, medium, or low.
- **Step 4:** Create an interest-power chart (Figure 32.3) that maps out the various stakeholders based on their level of interest (on x-axis) and power (on y-axis).

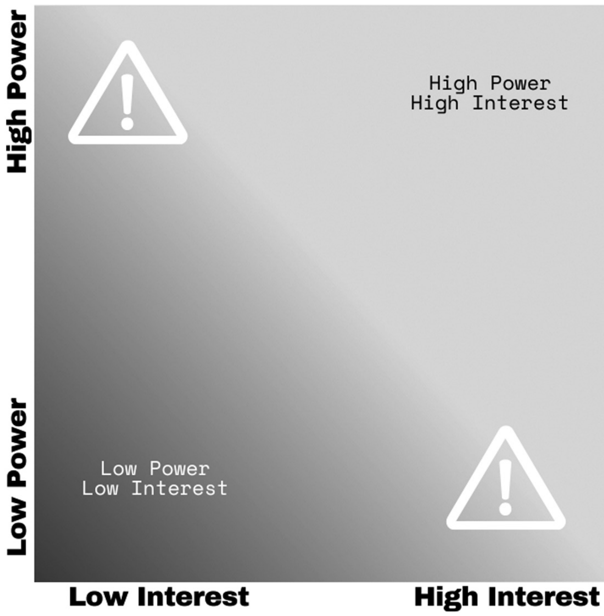

FIGURE 32.3 Power-interest chart to foster stakeholder analysis.

The stakeholders on the bottom-right part of the interest-power chart should be a primary consideration of the design team, as this is the group that is likely to be most disadvantaged from the outcome of the design process. The design team also needs to consider the impact of undue influence from stakeholders in the top left corner of the chart. These individuals and groups have significant power over the system but may not recognise the implications of their power due to their low interest in the system, i.e. the proverbial bull in a china shop. While the analysis can be carried out as an individual, a team-based approach with an external facilitator can minimise individual subconscious bias and groupthink.

Teamwork

Teamwork is widely recognised as a critical area in engineering, since much of engineering practice and design is conducted in a team setting; additionally, this aspect of engineering is explicitly mentioned in accreditation, specifically Student Outcome 5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

In the classroom and in practice, teamwork involves more than putting people together and expecting them to function as a team. Being intentional about teamwork can enhance IDEA in engineering practice and design. Instruction on teams and teamwork is important. All team members should understand team dynamics and the best practices of teams (Katzenbach & Smith, 1993; Tuckman, 1965), as well as the ability to take on task roles (recorder, facilitator, gatekeeper, etc.) and behavioural roles (giving input, encouraging, evaluating, etc.). Providing teams with methods to resolve conflict, and a working knowledge of "problem characters" and strategies to avoid them are also important (Jalajas & Sutton, 1984). Finally, creating written documents such as team constitutions, at the outset of a collaboration, encourages teams to stick to the intentions and principles that they set and declare, and can provide clarity at difficult junctures.

We recognise that teamwork is a skill that employers desire in graduates and an essential learning skill, given the extent to which we expect students to work in teams. Therefore, it is crucial that we formalise the act of teaching and assessing teamwork in our curriculum. A good example of a research-based system that can be used for this purpose is the Comprehensive Assessment of Team Member Effectiveness (CATME), which provides detailed terminology about teaming, the ability to intentionally form teams, and fostering constructive peer-evaluation (Loughry et al., 2014).

Teaming fundamentals alone, while critical for the strong functioning of teams, are not in and of themselves sufficient to ensure that IDEA is practised in design. Toward this end, individuals can get a better sense of their implicit bias (https://implicit.harvard.edu/implicit/takeatest.html) and privilege (Chugh, 2018), and as a team, can become familiar with and use liberating structures (https://www.liberatingstructures.com/), which are methods intended to equitably involve everyone in teaming activities.

Role of Community

The community can (and we argue should) play a key role in engineering design. Historically, the design process has not been transparent to those outside of the process. There have been some efforts to engage the community (often defined as "the users") in the design process (Dieter & Schmidt, 2013), but these approaches tend more toward having potential users of a design surveyed for their opinions at the outset of the process, or testing prototypes of a design concept for feedback and subsequent iteration. Though these approaches increase the role of the community in the design, they still leave the design process itself solely to the engineers. In fact, some engineers have the attitude that they need to "dumb down" their elegant creations for the consumer.

A human-centred design approach (Lima & Oakes, 2014) appreciates and respects those who will use the design, but still falls short of the ideal, which is engaging people who will use the design throughout the design process. This approach doesn't mean that engineers need community members to understand the specifics of all design processes, any more than community members need engineers to understand everything about their expertise; the idea is to use our complementary knowledge and skills at each step of the process to co-create an artefact. Regardless of whether or not community members have an engineering background, they can co-design with creative ideas, making and examining the veracity of assumptions, and providing insights that engineers do not have. Bergeron et al. (2019) present a set of principles for community-based design.

Community-based participatory research (CBPR) approaches are well-defined in literature and practice, particularly in health fields, where researchers sought to achieve better health outcomes for patients (Brush et al., 2020; Minkler, 2005). The recognition that "one size does not fit all" and the importance of context and community drove adoption of these approaches. We propose to extend CBPR approaches to engineering, i.e. to practice community-based participatory design, which would, at best, involve the community equitably in terms of power sharing and decision making, and in collaboration across every step of the process (Israel et al., 2001). We have not seen this term previously in the literature, though we believe that there are ample examples of such approaches in the literature: see issues of *The International Journal for Service Learning in Engineering, Humanitarian Engineering, and Social Entrepreneurship* for examples generally. Some specific articles of interest include Leidig and Oakes (2021) and Wixom et al. (2022). We believe that this area of research is new and critical for future development.

Social Justice

The work done in social justice in engineering is a useful lens through which to incorporate IDEA into engineering (Leydens et al., 2022). Leydens and Lucena (2018) present six criteria for engineering for social justice (p. 21). These criteria are further detailed below.

- **Listening Contextually.** This means practising active listening in which hearing the words is only the first step. It is also understanding point of view, context, and perspective with an open mind and heart. Sometimes listening to what is NOT said is an important part of contextual listening. One quote that illustrates the pitfalls of not listening contextually is this: Engineers often walk into the community with the answers when they don't even know the questions.
- **Identifying Structural Conditions.** Identifying those systems, practices, or factors that limit the possibilities of some – for example, wealth inequality, racism, lack of accessibility to health care or clean air, etc. Designing with these conditions in mind is one way to practise engineering with an eye toward IDEA (and a more just world).
- **Acknowledging Political Agency/Mobilising Power.** Political agency and power are factors that are present in all engineering contexts. Engineers need to acknowledge these factors to realise imbedded assumptions and ways of operating that may keep others out (for example, historically underrepresented people being told, "You are not a real engineer"), or may drive engineering practice in particular directions that are antithetical to IDEA and may go unnoticed and thus unaddressed (technology taking precedence over people, profit over sustainability, short-term payoff over long-term wellness, etc.).
- **Increasing Opportunities and Resources.** Looking at ways that engineering can increase opportunities for people (though enhanced access to goods, services, or use of design) and enhance their resources (to better conserve the planet's resources).
- **Reducing Imposed Risks and Harms.** Ensuring that engineering designs have minimal risks for those who use them is a concept that engineers are already familiar with due to codes of ethics. This concept can be broadened by looking at reduced risks and harms through the IDEA lens. Harms are not just physical; they can also be emotional or psychological.
- **Enhancing Human Capabilities**. Leydens and Lucena cite ten capabilities to consider during design (p. 29) as follows:
- Life (of a normal length)
- Bodily health
- Bodily integrity (freedom from assault and the ability to move about freely, etc.)
- Senses, imagination, and thought (which are critical to being fully human)
- Emotions (love, grief, longing, gratitude, and more)
- Practical reason (for critical thinking, freedom of conscience, etc.)
- Affiliation (including protecting institutions that advance compassion and ensuring the social preconditions for self-respect and non-humiliation regardless of sex, ethnicity, sexual orientation, etc.)
- Other species (how we manifest respect for plants, animals, and nature in general)
- Play (recreation, laughter)
- Control over one's political and material environment

Resilience and Learning from Failure

Failure analysis is core to engineering sciences. Testing materials to failure is often the goal of engineering testing. When a material fails, the properties of the material, such as mechanical strength, can be determined. Similarly, in weightlifting, athletes test their muscle strength by lifting the maximum weight they can handle. This approach allows the weightlifters to measure their overall strength. Developing skills to design from an IDEA perspective will push students to test their strength in many ways. Providing examples of using failure as an opportunity to grow – both personally and professionally – may help students shift their perspectives of failure in other areas of life to provide opportunities to learn and improve. Failure in this sense develops resilience.

Developing resilience and the ability to learn from failure in future engineers is an important skill to cultivate so that students can effectively respond to the complex challenges of their field. Fear of failure, even in the context of engineering design, is present beginning in elementary students (Lottero-Perdue & Parry, 2017). As engineers work to solve problems and achieve goals, they must be able to recognise and identify potential obstacles to develop solutions or effect positive change. This skill requires an ability to think critically and persist in the face of adversity. Developing resistance is essential for engineers to successfully tackle difficult engineering problems and navigate complex situations. Additionally, developing resilience can help engineers be more creative and innovative in their work, as they must be able to push beyond their comfort zones and explore new and creative solutions. Resilience can also help engineers remain motivated and focused on the task at hand, even when faced with numerous challenges.

Approaching design from an IDEA perspective will likely be a new experience for our students (and ourselves), which may result in failed attempts and attempting to move forward on wobbly footing. Failure may be a new and uncomfortable experience for engineering students, who often experience academic success. Supporting students in their experience of failure through resilience is vital to preparing IDEA-equipped engineers. The core concept of Dolly Chugh's book, *The Person You Mean to Be* (Chugh, 2018), is that striving toward IDEA excellence requires moving from being a "good person" to constantly striving to be a better person, with the idea that there is no such thing as perfection. This growth mindset develops humility and a willingness to consider other perspectives and life experiences.

Where Do We Go from Here?

Positionality Statements

We started this chapter with stories from our experiences as engineers and educators. We choose to include personal stories to illuminate the inherently personal component of an IDEA approach and to provide tangible examples of how we see IDEA principles play out in our professional lives. These experiences undoubtedly impact how we engage with this topic and our students. To this end, we provide our individual positionality statements (Secules et al., 2021) that provide a glimpse into our identities and experiences that shape our perspectives related to IDEA. Each of us are underrepresented in the engineering profession, and as such, negotiating issues around IDEA in engineering has been and continues to be a reality of our existence in this discipline, as well as an ideal that we endeavour to enhance. We believe awareness of our positionalities is a critical part of moving forward with work on integrating IDEA principles into engineering. We invite you to join us in this self-reflection.

Dr Deepak Keshwani: *I am a tenured Associate Professor and Director of Undergraduate Programmes at the University of Nebraska-Lincoln, an institution with a predominantly white student and faculty body. As a grandchild of refugees, and being an immigrant of colour myself, I identify as an outsider in the North American Higher Educational system while at the same time benefiting from my privilege as a cis-gendered male in a STEM field. I approach my teaching, scholarship, and service related through these salient identities. My motivation for IDEA-related scholarly endeavours stems from a concern about the impact of hyper-polarisation on the education and professional growth of students. This concern stems from my teaching and advising responsibilities that have provided me with extensive interactions with engineering and technology students. These interactions have led me to being involved in student success initiatives that connect to IDEA. For instance, I am currently involved in an institutional-level effort to scale up an ecology of validation model to support the academic success of at-promise students (first-generation, minority, low socio-economic status etc.). Being involved in this effort has forced me to confront my own biases and challenge assumptions I make about my students. My personal call to action is to examine my own pedagogical practices from an IDEA perspective and reimagine engineering curriculum to balance the technological and social aspects of our profession.*

Dr Jenny Keshwani: *I am a tenured Associate Professor and Science Literacy Specialist through Nebraska Extension. I grew up on a sugar beet farm in North Dakota. I studied biological systems engineering and biomedical engineering to eventually earn an interdisciplinary PhD in engineering and oral biology. For the past ten years, I have served as a faculty member in a Midwest R1 Engineering Department with a large extension appointment focused on K12 science and engineering education. I was a first-generation college student from out of state. I was a diligent student but was unprepared to study at a college level and lacked the confidence to ask questions or visit my professors during office hours. I was a solid B student. As a result, I don't value perfect grades and often tell my students that grades don't really reflect their learning or abilities. I encourage my students to push themselves beyond their comfort zone without considering impacts on their GPA and often remind my classes that learning is the goal – not accumulating points. I find identity in my strength in empathy and drive to be an "includer", which led me to build community within my classes and colleagues. My "includer-ness" bolsters my interest in IDEA work. As a result, I lead the Cultivate ACCESS (Agriculture Career Communities to Empower Students in STEM) virtual mentoring programme to empower high school students historically excluded from STEM-related agricultural careers. I also intentionally create community within my classes, teams, and colleagues through team-based activities and by focusing on the whole person during interactions. My work as a science literacy specialist allows me to broaden the participation of educators and students in STEM areas by making science and engineering accessible and meaningful through cultural awareness and personally relevant problem solving. I regularly meet with a community of "Paradigm Shifters" representing various aspects of the education and agroecosystem sectors to practise systems-thinking skills and identify ways to have a positive impact through the small and large aspects of our influence and privilege. I'm thankful for our conversations and how we challenge each other to continue on the journey of becoming better versions of ourselves.*

Dr Marybeth Lima: *I am a tenured professor in biological and agricultural engineering at Louisiana State University, and for the past three years, I have served as Department Chair. I became interested in the Chair position as the result of volunteer experiences I had during COVID. I sought to combat my feeling of uselessness during the summer of 2020 by volunteering at an elementary school I had previously collaborated with on a playground project. The school was serving as a food distribution centre for area children in need, and I was tasked with passing out milk each Wednesday morning during June and July. I became friendly with other volunteers, including members of an LSU men's sports team, who were volunteering to give boxes of non-perishables that were donated by a local company. In this capacity, I had a series of experiences in which (1) I did not speak up at a critical juncture when something* *culturally inappropriate was said (I returned the next week to talk to this person and he had been transferred to another location. I never saw him again); (2) I spoke up at a subsequent critical juncture and, in so doing, opened up a space in which other volunteers were supported; (3) I witnessed the sports team volunteers giving too much food to people in line – they ignored the asked-for amounts and overloaded people (against their will) in an effort to finish early – I confronted the student in charge of the group (he was in charge only for this week, as the company employee who had supervised these students each week was on vacation), who happened to be an engineering student. He told me it was none of my business, and that I couldn't control what he and his group did. They continued piling on food, over the loud complaining of the people in line. The group finished two hours early and people in line after that had no food, only the milk my station was distributing; and (4) being exposed to COVID in the ensuing week, and being unable to return to the site to tell the person who had been on vacation what had happened while he was gone. Through this series of experiences, I was reminded of the critical role of IDEA in engineering and in community, and I sought a leadership role in the hopes that, at least in my department, no engineering student would prioritise their interest in finishing early over children going hungry. I have established a committee on diversity, equity, and inclusion, comprised of all departmental constituents, but mostly students; together, we are working toward creating an environment where all feel welcomed, valued, respected, and engaged.*

Call to Action

In this chapter, we described IDEA's role in ABE and highlighted why these skills are important for future engineers to develop. We also provided strategies to implement in engineering education programmes that can equip students with the ability to consider the diverse needs of all users and stakeholders in the design process. As educators in ABE programmes, it is our responsibility to create opportunities for ourselves and our students to practise IDEA principles. We must foster a culture within our departments and university communities that values IDEA-grounded practices. Our students learn from the educational experiences we provide in the classroom and from their extracurricular activities and observations. How we interact with our colleagues and treat others, the awards and accomplishments we celebrate, and the leaders we choose and follow all shape their understanding of what it means to be a professional engineer. Therefore, it is crucial that we model and promote inclusive behaviour and practices in all these areas. There are several actions we can take collectively and individually to make progress toward imbedding IDEA into the field of agricultural and biological engineering. Here are some of our recommendations for next steps.

Actions for the Profession

- A concerted effort by our professional society is needed to develop case studies and other curricular supports focused on IDEA.
- Increased participation in/with organisations such as the American Society for Engineering Education, where critical dialogue and scholarship related to IDEA in an engineering context is occurring.
- Examination of systemic barriers to the participation and success of underrepresented groups in our profession, and execution of subsequent plans to eliminate these barriers.
- Establish an IDEA-focused student design competition through a professional society, such as ASABE.
- Break down the silos that divide technical content areas. We do our professionals, students, and stakeholders a disservice by suggesting that the decisions made in one sector do not have systemic impacts.
- Break down the wall between social and technical considerations. Engineering is a sociotechnical practice (Cech, 2014); we should explicate the role of humanities in engineering, as we do with math, science, and engineering fundamentals.

Actions for Academic Programmes

- Integrate engineering ethics across the curriculum using a formalised theory or framework to ensure repeated exposure.
- Integrate stakeholder analysis in the curriculum for engineering design classes.
- Increase student awareness of concepts such unconscious bias and groupthink.
- Incorporate activities to develop and practise systems-thinking habits in coursework.
- Integrate principles of humanities and social sciences into core engineering courses. Model to students that a variety of skills are essential to become an ABE professional – not just science and engineering knowledge.
- Include activities and opportunities across the curriculum that require students to use IDEA principles and practices.

Actions for Individuals

- Participate in professional development to gain knowledge of ethical theories and frameworks and their application to engineering situations, and the ability to integrate social and cultural contexts into disciplinary courses.
- Pursue IDEA-related self-development through assessments such as the Intercultural Development Inventory, implicit association tests, etc.
- Practise systems-thinking habits in daily interactions and projects. Read systems thinking books and discuss with a small group of colleagues. A couple of our favourites are cited in the systems thinking section.

We believe that engineering can be a force for good in the world, as we simultaneously agree with Donna Riley's concerns: “We accept too readily the facile self-aggrandising pronouncements of members of the profession that *engineers help society*. To truly answer the question of what engineering has to do with justice, we must also be willing to examine closely and carefully what engineering has to do with injustice” (Leydens & Lucena, 2018, p. xvii).

In order for engineering to be a force toward a more just world, we believe that it is critical to centre IDEA principles in the practice of engineering, including the people (engineers and non-engineers), the designed artefact, the design process, and the larger systems of which we are a part. This work isn’t easy, but it’s important and we believe it must be done.

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