Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #47797

Virtuous Engineering

Dr. Charles E. Baukal Jr. P.E., Oklahoma Baptist University

Charles E. Baukal, Jr. has a Ph.D. in Mechanical Engineering, an Ed.D., and Professional Engineering License. He is the Director of Engineering. He has over 40 years of industrial experience.

Virtuous Engineering

Abstract

Much has been written about engineering ethics, particularly related to codes and standards. However, those codes and standards are based primarily on protecting the public and not on virtues. It is argued here that virtue is a higher standard than ethics. While something may be ethical in terms of codes, standards, and industry norms, it may not be virtuous. Events in the author's experience will illustrate this point. These are presented as case studies where one is argued to be an example of non-virtuous engineering and one is presented as an example of virtuous engineering. In addition to two case studies, this paper will briefly consider the virtues relevant to engineering and discuss some factors related to ethics that impact equipment design and operations. The thesis of this paper is there may be a moral component in process and equipment design that goes beyond traditional engineering ethics training.

Introduction

Ethics, virtues, and morals are interrelated topics of interest here. Engineering ethics concerns rules and standards that govern external behavior. Engineering societies each have their own code of ethics designed to keep the public safe. It will be argued here that ethics are necessary, but not sufficient for engineers. Virtues are internal human traits such as integrity, honesty, and humility that are considered to be desirable in a person. As will be discussed later, there is no generally accepted set of virtues, but there are some virtues such as honesty and integrity that appear on many lists. It will be argued here that virtuous engineering should be the goal for engineers, which is a higher level than codes and standards. Morals are inner personal beliefs about what is right and wrong. They influence what someone considers to be ethical and virtuous. While many attempts have been made to define what is ethical, virtuous, and moral, there is no universal agreement, which is one reason why this is a challenging subject. Students learn how to calculate many things using formulas, but there are no formulas for virtuous behavior.

Some might argue that engineering is morally neutral, that it is strictly guided by well-accepted mathematics, science, and engineering principles. However, that is a somewhat naïve view because there may be considerable gray areas. Busby and Coeckelbergh (2003) [1] wrote, ". . . the picture of engineering as morally neutral is misleading. . . . Telling someone to develop a design for a hazardous installation, within the law and subject to prevailing engineering standards, does not relieve engineers of the moral burden of deciding, for example, whether certain kinds of maintenance staff should be put at risk by adopting certain designs." Taebi (2021) [2] wrote, "one persistent bias is the view that engineering is an unbiased and objective practice, because 'engineers deal with facts and figures, so there is no place for opinions or ethics in the practice of engineering.'" It is argued here there may be a moral component in equipment design, depending on the equipment and its application.

A complicating factor in designing equipment is that engineers may sometimes disagree with their employers over ethics. A famous example is the Space Shuttle Challenger accident where engineers recommended against launch in cold weather conditions but were overruled by management leading to disastrous results [3]. A recent study by the Royal Academy of Engineering (2023) shows the potential disparity between engineers and their employers (see Table 1).

Table 1 Results of a Royal Academy of Engineering study of engineers' and technicians' opinions on ethics [4].

Statement	% Agreeing
Profitability sometimes prioritized over fitness for purpose.	36
Sometimes have to accept situations I would characterize as professional or ethical misconduct.	45
Asked to take shortcuts I feel are unacceptable.	48
Work I have to undertake makes me feel ethically compromised.	53
Often find myself at odds with my employer when it comes to acting ethically.	58

Engineering ethics are extremely important because of the potential danger of some types of equipment. The author spent an entire career working on industrial combustion equipment which is inherently dangerous. Failure to properly design, build, operate, and maintain such equipment can lead to serious injuries and even fatalities.

According to the National Academy of Engineering (2016) [5], ethics are crucial in engineering, "Ethical practice in engineering is critical for ensuring public trust in the field and in its practitioners, especially as engineers increasingly tackle international and socially complex problems that combine technical and ethical challenges." Arthur Scwartz, Deputy Chief Executive Officer of the National Society of Professional Engineers, (2022) wrote [6],

> Are there many more significant issues confronting our society today than engineering ethics? I do not think so. . . . Because of the profound role that professional engineers possess in conceptualizing, designing, building, manufacturing, operating, maintaining, and disassembling products, structures, buildings, systems, processes, and others we live in, walk in, drive in, eat, drink, and breathe, few issues could be more important to us.

This importance is re-iterated in ABET Criterion 3, Student Outcome 4 [7] which states that graduating students should be able to demonstrate "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."

It is important to train engineers in ethics for many reasons (Schlossberger, 2023) [8]:

1. Many of the ethical decisions made by individual engineers must make are not settled by rules.
2. Individual engineers sometimes confront ethical issues in their own work.
3. Organizations function best when the values implicit in the rules and executive decisions are widely understood and discussed within the organization.

4. Engineers who understand the ethical dimensions of engineering are better and happier engineers.

Abaté (2011) [9] argued the goal of teaching engineering ethics is not to teach morality and should only concern teaching professional ethics such as those in the engineering codes of ethics. He wrote, "the ultimate aim of efforts to teach engineering ethics is not to produce moral engineers, but rather to instill careful clarity of insight and cogent decision-making skills." This author agrees with that to an extent but believes that students should at least be introduced to virtuous engineering.

Luegenbiehl (2010) [10] listed the following as foundational principles of engineering ethics:

- ***Public Safety***: Engineers should endeavor, based on their expertise, to keep members of the public safe from serious negative physical consequences resulting from their development and implementation of technology.
- ***Human Rights***: Engineers should endeavor to ensure that fundamental rights of human beings will not be negatively impacted as a result of their work with technology.
- ***Environmental and Animal Preservation***: Engineers should endeavor to avoid damage to the animal kingdom and the natural environment which would result in serious negative consequences, including long-term ones, to human life.
- ***Engineering Competence***: Engineers should endeavor to engage only in engineering activities which they are competent to carry out.
- ***Scientifically Founded Judgment***: Engineers should endeavor to base their engineering decisions on scientific principles and mathematical analysis, and seek to avoid the influence of extraneous factors.
- ***Openness and Honesty***: Engineers should endeavor to keep the public informed of their decisions which have the potential to seriously affect the public, and to be truthful and complete in their disclosures.

McGinn (2018) [11] listed four fundamental ethical responsibilities of engineers:

1. ***To not cause harm or create unreasonable risk*** to others (or to public welfare or the public interest) through their engineering work.
2. ***To try to prevent harm and any unreasonable risk of harm*** to others (and to public welfare and public interest) that is caused by the engineering work of others in which they are involved, or about which they are technically knowledgeable.
3. ***To try to alert and inform about the risk of harm*** those individuals and segments of the public at unreasonable risk of being harmed by their engineering work, by the engineering work of others in which they are involved, or about which they are technically knowledgeable.
4. ***To work to the best of their ability to serve the legitimate interests of their employer or client.***

It may be argued that true virtuous engineering is overkill and not practical. Shouldn't an industrial end-user be responsible for properly installing, operating, and maintaining the equipment in their plant? The easy answer is yes, but the problem is that sometimes the end-user does not know what they don't know. In some cases, that could lead to catastrophic results. It is argued here that going beyond the codes, standards, and accepted practices does not necessarily mean a significant increase in cost and schedule. While virtues have been discussed throughout history, there has been relatively little discussion of virtues in the context of engineering.

Virtue

A great deal has been written about virtue over millennia. Plato (c. 380 BC) [12] defined virtue as "the health and beauty and well-being of the soul." Jonathan Edwards (1765) [13] defined virtue as "the beauty of those qualities and acts of the mind, that are of a moral nature." Annas (2011) [14] defined virtue as "a lasting feature of a person, a tendency for the person to be a certain way. It is not merely a lasting feature, however, one that just sits there undisturbed. It is *active:* to have it is to be disposed to act in certain ways. And it *develops* through selective response to circumstances." Boyd and Timpe (2021) [15] defined virtue as "an excellent and stable quality of the soul that enables a person to act well regarding some activity." Only a few selected aspects of virtue believed to be relevant to engineering will be briefly discussed here.

It may be argued a guideline that should be adhered to when designing potentially dangerous equipment is to follow the golden rule which historically was to treat others as one would like to be treated. The more modern version is to treat others as they would like to be treated. It is assumed that most people would want to have equipment they will be using to be as safe as possible. At a minimum, it is expected the equipment will meet all legal requirements, but it is at least hoped all reasonable means are employed to keep the user safe.

Catalano (2006) [16] argued there are two fundamental principles espoused by multiple engineering codes of ethics: (1) hold paramount the safety, health and welfare of the public and (2) uphold and advance the engineering profession. In the latter, integrity, honor, and dignity are given as key components. These are considered by many to be virtues.

Some representative and relevant lists of virtues are given next. Kreeft (1992) [17] listed the cardinal virtues as justice, wisdom, courage, and moderation. Williams (2019) [18] listed the 12 core virtues at the West Point Military Academy as: compassion, courage, dedication, determination, dignity, discipline, integrity, loyalty, perseverance, responsibility, service, and trust. Boyd and Timpe (2021) [15] argued the following six virtues exist in all cultures for all times: courage, justice, humanity, temperance, transcendence, and wisdom.

Vallor (2016) [19] listed a dozen what she called *technomoral* virtues which connect virtue and technology:

1. Honesty (trust, reliability, integrity)
2. Self-control (temperance, discipline, moderation, patience)
3. Humility (modesty, reverence, wonder)
4. Justice (responsibility, fairness, reciprocity, beneficence)
5. Courage (hope, perseverance, fortitude)
6. Empathy (compassion, benevolence, sympathy, charity)

7. Care (generosity, love, service, charity)
8. Civility (respect, tolerance, engagement, friendship)
9. Flexibility (patience, forbearance, tolerance, equanimity, mercy)
10. Perspective (discernment, attention, understanding)
11. Magnanimity (equanimity, courage, ambition)
12. Technomoral Wisdom (unifies the virtues)

Some authors listed virtues desirable for engineers. Moriarity (2008) [20] listed objectivity, care, and honesty. Van de Poel and Greenberg (2010) [10] recommended fairness, honesty, and care. Frezza and Greenly (2021) [21] proposed prudence, disinterestedness, truthfulness, and justice. Schmidt (2021) [22] suggested justice, courage, and honesty. All four included honesty or truthfulness. Stovall (2011) [23] argued for the somewhat unique virtue of professional self-awareness which properly considers the desire for personal achievement and the practical constraints in a project. Koehler et al. (2020) [24] published an extensive literature review of four prominent virtues in undergraduate engineering education: (1) critical thinking (intellectual virtue), (2) empathy (moral virtue), (3) service (civic virtue), and (4) teamwork (performance virtue). They wrote (p. 17), “When engineers exercise intellectual, moral, civic, and performance virtues consistently and reliably towards morally good ends, they would not only be good, but do good in the world.” This author tentatively proposes the following list of virtues for engineers: wisdom (includes competence), integrity (includes honesty), communication, humility, and courage.

A question that might be asked is how does a list of virtues translate into a virtuous person? While a complete treatment of that is beyond the scope of this paper, it seems to this author that this evolves and develops over time and with experience. While a few books or lectures or even an entire course on virtues would be helpful in initially helping someone into becoming a virtuous person, they are unlikely to be sufficient. Knowledge is important but real-world experience tests that knowledge and helps one ultimately determine what they believe is virtuous. As will be shown in the case studies discussed here, the author’s own journey has helped to refine thoughts and beliefs on what it means to be virtuous, particularly in the context of engineering. Students learning about engineering codes and standards is a first step on the road to becoming virtuous engineers.

Virtue Ethics

A branch of ethics called *virtue ethics* “evaluates actions in terms of virtue, for example, by holding that an action is right if and only if it is what a virtuous person would characteristically do in the circumstances” [25]. It can be described as [26]:

1) an ethics that is “agent-centered” rather than “act-centered”
2) concerned with Being rather than Doing
3) addressing itself to the question, “What sort of person should I be?” rather than to the question, “What sorts of action should I do?”
4) taking certain areteic concepts (good, excellence, virtue) as basic rather than deontic ones (right, duty, obligation)

5) rejecting the idea that ethics is codified in rules or principles that can provide specific action guidance.

The last item is of particular interest here where it is argued that there will not always be specific codes, rules, or accepted practices that govern all designs, particularly in newer areas of technology such as artificial intelligence.

Charles Harris (2008) [27, p. 153] wrote this about virtue ethics as applied to engineering:

> During the past few decades, engineering ethics has been oriented towards protecting the public from professional misconduct by engineers and from the harmful effects of technology. This ‘‘preventive ethics’’ project has been accomplished primarily by means of the promulgation of negative rules. However, some aspects of engineering professionalism, such as (1) sensitivity to risk (2) awareness of the social context of technology, (3) respect for nature, and (4) commitment to the public good, cannot be adequately accounted for in terms of rules, certainly not negative rules. Virtue ethics is a more appropriate vehicle for expressing these aspects of engineering professionalism. Some of the unique features of virtue ethics are the greater place it gives for discretion and judgment and also for inner motivation and commitment.

Reijers and Gordijn (2019) [28] argued that virtuous practice design (VPD) based on virtue ethics is more effective than value sensitive design (VSD). Pierrakos et al. (2023) [29, p. 1] wrote, “Virtuous engineers are responsible engineers who use their judgment to balance conflicting demands.”

Factors Affecting Design and Operations

While there are numerous factors that affect the design and operations of equipment (e.g., schedule, budget, and performance requirements), this section briefly considers some factors concerning engineering ethics.

<u>External Legal</u>

This refers to published rules, regulations, and codes as well as to usually generally-accepted but often unpublished industry standards. For example, the ASME Boiler and Pressure Vessel Code, originally published in 1915, gives minimum specific design guidelines that must be met to ensure safety. This code has become part of the law in jurisdictions worldwide. Failure to meet this code typically means failure to receive government approval. An important consequence is that any equipment failing to meet applicable codes is not likely to be insurable. These written codes must be strictly followed.

Equipment that fails to meet industry standards does not normally impact government approval or insurability, but rather it may impact its marketability. These industry standards are not normally legal requirements but are often written into equipment specifications used for procurement purposes and have the effect of something close to a legal requirement. If there were to be a safety problem caused by failure to meet accepted and well-known industry standards, there could be legal consequences for the supplier. The argument would be the supplier should have known these standards even if they are not officially published anywhere.

Internal Legal

This refers to guidelines set by the legal department within an organization. These are above and beyond external legal requirements. These are commonly seen in the manuals that accompany engineered equipment. For example, power tools come with extensive manuals filled with numerous safety warnings and instructions. One such instruction is not to put power tools in water. While this should be obvious to anyone operating powered equipment, it is still included to help protect the manufacturer from litigation.

These warnings are usually not specifically required by external legal requirements. Since very few lawyers have the requisite technical training, the manuals are normally written by engineers and reviewed by legal. Lawyers are not normally reviewing the manuals for technical accuracy, but to make sure they adequately protect their employers from possible litigation if something should go wrong, even if it was not the fault of the supplier. Unfortunately, these technical manuals have grown substantially in length to include all the possible things that might go wrong with the equipment, no matter how remote the possibility. It used to be assumed those purchasing the equipment would only have qualified personnel installing, operating, and maintaining the equipment. However, that is no longer assumed so everything must now be spelled out in some detail. This is unfortunate because it is well known by vendors that these thick and detailed manuals are usually put on a shelf and rarely consulted. Even worse, they often fail to even get into the hands of those who should have them and may reside with someone, for example, in procurement, who will not be installing, operating, or maintaining the equipment.

Having worked with many corporate lawyers over the years, the author's experience is that in relation to equipment they fall into two categories. The first includes those that are risk-averse and can make it very challenging to sell potentially dangerous equipment. For them, profit is not usually a significant consideration. The second category includes those who understand that certain types of equipment are inherently dangerous. They do their best to minimize the legal exposure of their employers with minimal restrictions on the company's ability to sell the equipment.

Safety Devices

Engineered safety devices are designed to protect people from injuries and potentially from fatalities. When initially designed and manufactured, they may be too expensive for widespread required use and may be offered as an optional accessory. In fact, vendors often use these somewhat unique options as selling points to help distinguish their products from their competitors. As their use becomes more ubiquitous and the costs go down, they may become external legal requirements. One example is air bags in automobiles which have become standard requirement. Another example is smoke detectors and carbon monoxide sensors (for houses that have gas- or oil-fired appliances) that have become requirements for new houses.

Until these safety devices become legal requirements, the question for equipment manufacturers is whether or not to include them as standard equipment. If they are included and are still somewhat expensive, this can put suppliers incorporating them at a cost disadvantage in the marketplace. It might be argued they should be offered as options until they become legally required. That would be legal and ethical, but would it be virtuous?

Case Studies

It is common to use case studies to teach engineering ethics (e.g., [30]). While it is necessary to discuss ethics in a general sense, case studies help illustrate the complexities in real-life situations which are not always as cut and dried as they may appear in a textbook. The case studies presented here are based on the author's personal experiences. In both cases, the engineers acted legally and ethically. However, it is argued the first case was non-virtuous and the second was virtuous.

Non-Virtuous Engineering

The author's employer (*Vendor 1*) designed, fabricated, and delivered equipment designed to distribute a protective atmosphere containing hydrogen and nitrogen for use in metal heat treating. The equipment was designed according to a rigorous national standard. The client contacted Vendor 1, some time after the equipment had already been in operation, asking for someone to inspect the installation. As a relatively new engineer who designed this type of equipment at the time, the author was sent to the client to inspect the installation. It was immediately apparent the client was manually operating the controls which bypassed the safety equipment which was installed but never connected. It was believed this was out of ignorance and not malice. Hydrogen leaks from piping systems very easily, is highly volatile and explosive, and requires very minimal energy to ignite. There were open flames in the vicinity of the hydrogen-nitrogen blending system. The author has never forgotten physically shaking in the car while driving away from the plant because of the realization that this potentially explosive situation could have killed the author and many of the plant workers.

The author sent the client follow-up instructions after the visit concerning how to connect the safety equipment. Those instructions were already contained in the very detailed, extensive, and thick manual that had been sent with the equipment. Based on Vendor 1's experience, while much time was devoted to creating those manuals, it was well known that most clients paid little attention to them. Sending potentially dangerous equipment to clients and assuming they would install it properly was completely legal and ethical, but was it virtuous? In hindsight, it is argued here that it was not. At a minimum, vendors of such equipment could require an inspection of the installation to ensure it is safe. Even further, they might require some type of end user training to ensure the equipment is being properly installed, operated, and maintained. It is unknown to the author if the client ever did carry out the instructions and connect the safety equipment.

Virtuous Engineering

The author's employer (different than the one above; *Vendor 2*) designed, fabricated, and delivered industrial combustion equipment intended to provide heat in a furnace used in the production of chemicals. This type of furnace has an upstream set of burners inside the main combustion chamber and a second set of burners downstream from that chamber. A field service engineer, a colleague of the author at the time, found Vendor 2's equipment was not being properly operated at a particular plant. The upstream burners were being overfired by about 25%, while the downstream burners were shut off. This created a potentially very dangerous situation where the upstream burners had severely lifted and unstable flames that could have possibly flamed out and then re-ignited leading to an explosion. Because of the large amount of fuel being used, this could have been a catastrophic event.

The field service engineer immediately notified the operators of this potentially very hazardous situation. Their response was the equipment was being operated according to the company guidelines they were given, so the engineer would have to talk to their supervisors. Ultimately, the field service engineer worked all the way up to the plant manager, who was the highest ranking person at the plant. His response was the equipment had been operated that way for a long period of time and he did not want to do anything that might jeopardize production. The plant was run 24 hours/day, 365 days a year. It is important to note that plant managers commonly receive performance bonuses based on productivity.

Another important aspect of this case study is that the plant in question had multiple sister plants (also customers of Vendor 2) with essentially the same equipment, but operating it as intended with the upstream burners fired at their design rate and the downstream burners firing at their design rate. This fact did not dissuade the plant in question from modifying their operating practice. It appeared to Vendor 2 that the plants were in competition with each other and acted somewhat independently.

It might be argued the field service engineer did his due diligence in this situation. It is also important to note the manual provided with the equipment clearly stated the proper operating procedures which were not being followed. However, that was not sufficient for the field service engineer who convinced his own legal department to send a letter to the client putting them on notice about the very dangerous operating conditions at the plant. Needless to say, it is not generally advisable to highlight a client's unethical behavior if you want to keep that client. The field service engineer did everything in his power to fix this dangerous condition. This client eventually switched to another vendor for their burners. It is unknown if that was related to the whistleblowing by the field service engineer. It is also unknown whether the client ever fixed the dangerous condition, but they had not corrected it while the field service engineer was still responsible for that plant. There were no consequences for the field service engineer, either positive or negative, for exposing this very dangerous condition.

Conclusions

Compared to other professions, the stakes are often much higher for engineers because of the potential to harm people and the environment, which is why engineering ethics are so important. Davis (2012) [31] made a profound statement regarding the importance of good judgment for engineers, "There is no good engineering, no good science, and so on without good judgment and no good judgment in these disciplines without ethics." Because it is impossible to have written rules and regulations for every possible scenario, it is critical for engineers to exercise good judgment. It is argued here that processes and equipment that meet codes and standards may be ethical, but not virtuous.

Most of the engineering codes of ethics contain similar language, but while there are many lists of virtues, there is no generally accepted set of virtues. Rubin (2015) [32] argued there are no generally accepted principles of morality. While it is generally clear whether engineered equipment meets stated and well-defined codes, standards, and industry norms, it is much less clear if the design and operation are virtuous.

The purpose here is not to be prescriptive about what virtuous engineering means as that would be impossible to do. The purpose is to continue the conversation about how to educate engineering students not only on ethics, but to take it to a higher level referred to here as *virtuous engineering*.

Recommendations

Nearly all university engineering programs provide at least some training for students in ethics as required by ABET. Unfortunately, it is often in one or a limited number of courses, rather than interspersed throughout the curriculum. It might be argued that instruction in ethics might be out of place in highly technical courses like statics and thermodynamics. However, it would be relatively easy to put a case study or two in such courses that show the result of unethical behavior related to the topic. For example, the 1981 Hyatt Regency walkway collapse led to the death of 114 people due to a cost-saving manufacturing decision that caused the structural failure of some hangars [33] that would have been designed by engineers using statics.

A suggestion for how the case studies presented here might be used in the classroom is to present the facts and then ask students what they would have done in those situations. Then the instructor could present what was actually done and ask the students to decide whether those actions were ethical and lawful and then whether the actions were virtuous. Students should defend their answers so the instructor can see how they came to their conclusions. This will likely lead to further discussions about applying ethics and virtues to actual engineering scenarios which are rarely black and white and may have many shades of gray. This is why virtuous engineering can be so challenging as there are no formulas to solve the problems as students become accustomed to using to solve their technical problems.

References

1. J. Busby and M. Coeckelbergh, “The Social Ascription of Obligations to Engineers,” *Science and Engineering Ethics*, vol. 9, pp. 363-376, 2003.
2. B. Taebi, *Ethics & Engineering: An Introduction*. Cambridge, UK: Cambridge University Press, 2021.
3. D. Vaughn, *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago: University of Chicago Press, 2023.

4. Royal Academy of Engineering, "Ethics in the Engineering Profession," London: GoodCorporation Ltd, June 2023.
5. National Academy of Engineering, "Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs," Washington, DC: National Academy Press, 2016.
6. H. Furey, S. Hill, and S. Bhatia, *Beyond the Code: A Philosophical Guide to Engineering Ethics*. New York, NY: Routledge, 2022, p. xi.
7. ABET, "ABET Engineering Accreditation Commission 2024-2025 Criteria for Accrediting Engineering Programs," Baltimore, MD: ABET, 2023, p. 6.
8. E. Schlossberger, *Ethical Engineering: A Practical Guide with Case Studies*. Boca Raton, FL: CRC Press, 2023.
9. C. Abaté, "Should Engineering Ethics Be Taught," *Science and Engineering Ethics*, vol. 17, pp. 583-596, 2011.
10. I. van de Poel and D. Goldberg, *Philosophy & Engineering: An Emerging Agenda*. Netherlands: Springer, 2010.
11. R. McGinn, *The Ethical Engineer: Contemporary Concepts & Cases*. Princeton, NJ: Princeton University Press, 2018.
12. Plato, *The Republic*. New Delhi: FingerPrint! Classics, 2023, p. 157.
13. J. Edwards, *The Nature of True Virtue*. Trigian, 2023.
14. J. Annas, *Intelligent Virtue*. Oxford, UK: Oxford University Press, 2011.
15. C. Boyd and K. Timpe, *The Virtues: A Very Short Introduction*. Oxford, UK: Oxford University Press, 2021.
16. G. Catalano, *Engineering Ethics: Peace, Justice, & the Earth*. San Rafael, CA: Morgan & Claypool, 2006.
17. P. Kreeft, *Back to Virtue: Traditional Moral Wisdom for Modern Moral Confusion*. San Francisco, CA: Ignatius Press, 1986).
18. P. Williams, *Character Carved in Stone: 12 Core Virtues of West Point that Build Leaders & Produce Success*. Grand Rapids, MI: Revell, 2019.
19. S. Vallor, *Technology and the Virtues: A Philosophical Guide to a Future Worth Wanting*. Oxford, UK: Oxford University Press, 2016.
20. G. Moriarity, *The Engineering Project: Its Nature, Ethics, and Promise*. College Park, PA: Penn State University Press, 2008.
21. S. Frezza and J. Greenly, "Identifying Core Engineering Virtues: Relating Competency and Virtue to Professional Codes of Ethics," paper 32332, 2021 ASEE Annual Conference, virtual meeting, July 26-29, 2021.
22. J. Schmidt, "Virtuous Engineers" in *Science, Technology, & Virtues*, Emanuele Ratti & Thomas Stapleford, Eds. Oxford, UK: Oxford University Press, 2021.
23. P. Stovall, "Professional Virtue and Professional Self-Awareness: A Case Study in Engineering Ethics," *Science and Engineering Ethics*, vol. 17, pp. 109-132, 2011.
24. J. Koehler, O. Pierrakos, M. Lamb, A. Demaske, C. Santos, M. Gross, and D. Brown, "What Can We Learn from Character Education? A Literature Review of Four Prominent Virtues in Engineering Education," paper 30371, 2020 ASEE Virtual Conference, June 22-26, 2020.
25. L. van Zyl, *Virtue Ethics: A Contemporary Introduction*. New York, NY: Routledge, 2019, p. 13.

26. R. Hursthouse, *On Virtue Ethics*. Oxford, UK: Oxford University Press, 1999, p. 25.
27. C. Harris, “The Good Engineer: Giving Virtue its Due in Engineering,” *Science and Engineering Ethics*, vol. 14, pp. 153-164, 2008.
28. W. Reijers and B. Gordijn, “Moving from value sensitive design to virtuous design practice,” *Journal of Information Communication and Ethics in Society*, vol. 17, no. 2, pp. 196-209, 2019.
29. O. Pierrakos, A. Yeaman, K. Luthy, and M. Gentile, “Moral and Civic Virtues in Engineering: Reimagining Engineering Ethics to Cultivate Virtuous Engineers,” 2023 IEEE Frontiers in Education Conference (FIE), College Station, TX, 2023, pp. 1-3.
30. C. Harris, M. Pritchard, R. James, E. Englehardt, and M. Rabins *Engineering Ethics: Concepts and Cases*, 6th Edition. Boston, MA: Cengage, 2019.
31. M. Davis, “A Plea for Judgment,” *Science and Engineering Ethics*, vol. 18, pp. 789-808, 2012.
32. C. Rubin, “Machine Morality and Human Responsibility,” in *Science, Virtue, & the Future of Humanity*, P. Lawler and M. Guerra, Eds. Lanham, MD: Lexington, 2015.
33. R. Marshall, E. Pfrang, E. Leyendecker, and K. Woodward, Investigation of the Kansas City Hyatt Regency Walkways Collapse, National Bureau of Standards report, 1982; https://nvlpubs.nist.gov/nistpubs/Legacy/BSS/nbsbuildingscience143.pdf.