Christopher P. Funk

Professor Nicholas D. Fila

CPRE 2320

13 March 2025

The Four Key Characteristics of an Ethical Engineer: Conviction, Care, Objectivity, and Competence

Engineers are fundamentally problem-solvers. Ethical problems form a subcategory of the problems a competent engineer must be capable of handling. An ethical component exists in every engineering design decision (Lloyd and Busby 2003), so the ability of an engineer to identify and effectively handle these ethical problems is critical. This ethical problem-solving process may be broken into four major steps: recognizing the relevant ethical considerations, correctly gauging their significance, choosing an appropriate solution, and implementing the solution. Just as an engineer must have certain technical qualities to solve technical problems, there are certain ethical qualities that are essential for handling each step of the ethical problem-solving process. These categories of ethical and technical qualities are not mutually exclusive.

I believe that there are four essential characteristics an engineer must possess to effectively solve ethical engineering problems. These characteristics are:

- Conviction – A distinct sense of which choices/outcomes are right and wrong.
- Care – A concern for others that permeates every decision.
- Objectivity – An ability to make fair decisions through a recognition of personal or outside factors that may cause bias.

- Competence – An ability to recognize ethical issues and the qualifications to distinguish between important and lesser ethical issues.

I aim to show how these four qualities are connected and foundational to the four steps of the engineer's ethical problem-solving process. It is important to note that I do not see these four characteristics as distinct. Instead, my intention is to show how each of these characteristics fits inside the other, progressing from the most generally applicable (conviction) to the most engineering-specific (competence) (see figure 1). In addition, I do not intend to suggest that an ethical engineer will master these characteristics. Rather, I see these characteristics as aspirational goals that engineers should strive to achieve. I believe these four characteristics can be shown to exist in every ethical engineering decision and lacking in every unethical engineering decision.

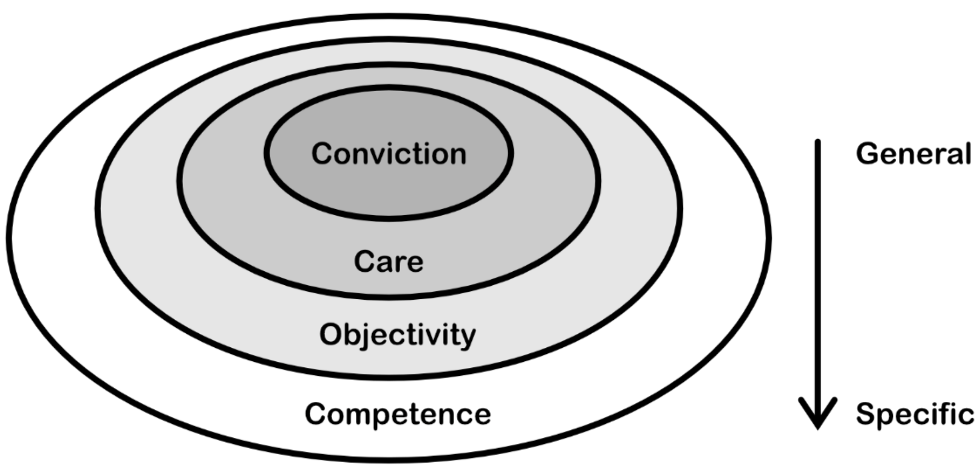

Figure 1. Relationship between the four essential characteristics of an ethical engineer

Conviction

To realize the relevant ethical considerations, an engineer must first have a sense of which choices are unethical. Therefore, an engineer's ethical characteristics must be anchored in a robust sense of right and wrong. An engineer must not merely care; they must care about the right thing. Before an engineer can be objective, the engineer must have a clear idea of what is fair. Before becoming competent, the engineer must first recognize their incompetence. What is right? What is good? These questions are challenging to discuss from a purely objective standpoint; as a result, many people see morality as consisting of both an objective and a subjective component (Dorsey 2012).

While there exists no universally accepted standard of morality, an engineer's convictions should rest on the more objective components of morality based on generally accepted moral guidelines such as Beauchamp and Childress's four principles of biomedical ethics: autonomy – Respecting an individual's right to make their own decisions, beneficence – Choosing to act in the best interest of others, non-maleficence – Avoid harming others, and justice – Acting with fairness and equity (Beauchamp and Childress 2013). However, without more explicit and comprehensive definitions, even a concept of morality based on these four principles is still relative to a person's views on autonomy, non-maleficence, beneficence, and justice. Due to this variance between beliefs, even narrowing the scope of morality down to these four principles does not fully dissipate the mystery around what qualifies as moral. Despite this uncertainty, engineers must hold convictions regarding morality to recognize ethical problems. A choice that does not feature both right and wrong solutions is not an ethical problem. Therefore, if an engineer claims to have discovered an ethical problem, they are suggesting that they have found a circumstance that features an outcome or outcomes that offer some improvement over other outcomes. Thus, ethical problems require that their discoverers hold a position on what is morally right. Because the characteristic of conviction I am advocating here is primarily concerned with how an engineer should know what they must do, this characteristic is strongly influenced by deontological ethics. If an engineer lacks concrete convictions or, more realistically, the right convictions regarding morality, they are liable to overlook, misidentify, or quickly dismiss ethical problems that necessitate careful consideration.

Care

Knowledge of right and wrong is not sufficient; in addition to knowing what is right, an engineer must react to their knowledge. This reaction must have a motivation. What should motivate the ethical engineer's reaction to an ethical problem? I believe that the engineer's reaction should be primarily motivated by consideration for others. While some may add other motivations like care for the earth and its environment, I believe these priorities should not be seen as distinct from or equally important to a person's responsibility to their fellow humans. Since the characteristic of care is concerned with who an engineer should be, relative to conviction, care is a more virtue-ethics-based characteristic.

Why should care for others be an engineer's primary motivator? To illustrate this point, consider an example of what can happen if engineering decisions do not feature care for others as a primary motivator.

In 2018, an email exchange occurred between an employee, McCallum, and his employer, Rush, a trained aerospace engineer responsible for overseeing the company's engineering design team and CEO of the deep-sea exploration company OceanGate Inc. McCallum expressed concerns to Rush that he did not have their company's patent submersible design certified by a third-party organization. In response, Rush stated:

> “I know that our engineering focused, innovative approach (as opposed to an existing standards compliance focused design process) flies in the face of the submersible orthodoxy, but that is the nature of innovation.
>
> …
>
> I have grown tired of industry players who try to use a safety argument to stop innovation and new entrants from entering their small existing market. Since Guillermo and I started OceanGate we have heard baseless cries of "you are going to kill someone" way too often. I take this as a serious personal insult.” (qtd. in, Francis, and Evans 2023)

The widely publicized story of the *Titan* implosion 5 years later, on June 18th, 2023, exposed this engineer’s tragic decision to disregard his employee and other engineers’ advice. While Rush had considered safety in the *Titan* submersible’s design (Estrada 2021), this exchange highlights that the safety of the submersible occupants was not of primary importance to Rush. Instead, Rush appears to view innovation and maintaining a competitive advantage as paramount. While some might argue that an example from a "disaster case" is not representative of everyday ethical decision-making, there are nonetheless many aspects that do relate to everyday engineering practice. This example demonstrates how easy it is to view the careful consideration of the well-being and safety of the end user as a simple problem that will be easily achieved as a side effect of an engineer’s prowess and pursuit of cutting-edge engineering innovation. Because of the danger of developing an attitude that sees the safety of the end user as a restrictive, uninteresting, or simple problem, the ethical engineer should seek to cultivate the virtue of care for others such that this care permeates every decision.

Objectivity

Another aspect that can be seen in this excerpt from the email exchange between Rush and McCallum is the pervasiveness of bias in Rush's reply. For example, when Rush states that he views other engineers' concerns about the safety of his design as a "personal insult," Rush seems to suggest that he views these criticisms as attacks on his engineering prowess.

Even an engineer who cares for others is susceptible to falling prey to various cognitive biases if they neglect to actively check for bias in their considerations. Confirmation bias – The tendency to selectively interpret data so that it confirms preconceived notions (Mohanani et al. 2020) and outcomes bias – Evaluating a decision based on an already known outcome (Gino, Moore, and Bazerman 2008) are both examples of cognitive biases which may affect an engineer's suboptimal decisions. In addition, there are other factors, real or imagined, such as peer pressure or pressures from management that, if not clearly realized, can influence an engineer to make decisions not in the best interest of others.

While complete objectivity, if achievable, would be ideal, it would be naïve to conclude that all biases must be eliminated and that engineering decisions must be made with complete objectivity. Because an engineer's objective assessments are made relative to their concept of right and wrong, and since this concept is not fully objective, complete objectivity cannot represent an engineer's real-life decision-making process. An additional factor that hinders perfect objectivity is a lack of empirical data, particularly a lack of data related to the outcomes of implementing emerging technologies.

As an example, consider the case presented by Vallero and Gunsch, where environmental engineers must decide on whether bioengineered microorganisms should be introduced into an environment to neutralize pollutants. The outcome space is too large to determine what might happen if these microorganisms are introduced into a new environment. In an attempt to support a utilitarian consequentialist objectivity, Vallero and Gunsch suggest a pseudo-objective approach to decision-making, where the engineers analyze the outcomes by giving each a weight based on a projection of the decision's consequences (Vallero and Gunsch 2020). While the approach that Vallero and Gunsch suggest may help an engineer keep track of the possible consequences, my concern is that it may also give the appearance of objectivity while serving as a trojan horse for various cognitive biases such as conformation and outcomes bias.

What, then, is the level of objectivity an engineer can hope to achieve? I would advocate that engineers should take an approach to bias mitigation based on expectable consequentialism. I believe two practices offer the best reasonably expected chances of reducing bias in decision-making and maintaining a relative objectivity: identifying the major biases that may be influencing a decision and consulting with engineers holding diverse perspectives. These mechanisms should be implemented as pre- and post-filters in an ethical engineer's pursuit of objectivity in ethical problem-solving.

Competence

While a clear knowledge of right and wrong, care for others, and a persistent pursuit of objectivity are all important characteristics of an ethical engineer, for an engineer to handle the four major stages in the ethical problem-solving process— recognizing, gauging, choosing, and implementing, they must also possess a certain level of technical competence. Take, for instance, a team of engineers tasked with assessing risks associated with a new AI model, like the Frontier Red Team at the AI developer Anthropic (Schechner 2024). Although every engineering problem contains an ethical component, not every ethical problem is of equal importance. To correctly weigh and target the ethical risks associated with a new AI model, an engineer must have an in-depth understanding of how the AI algorithm works.

If the engineer possesses an inadequate amount of in-depth understanding and technical ability, this engineer is likely to waste time and effort chasing after improbable scenarios while neglecting to test for more realistic and concerning possibilities, such as the AI model's ability to provide knowledge on various biological weapons (Schechner 2024) or generate biased and discriminatory responses. When an ethical issue is discovered, the engineer must be able to weigh the viable solutions and gauge their likely outcomes. This evaluation requires the engineer to have enough technical expertise in their discipline to realize feasible solutions to the ethical problem. Finally, the engineer must possess the ability and the knowledge to execute the solution in a thorough and skillful manner. Thus, an engineer capable of competently handling ethical problems must also be able to competently handle technical problems.

Conclusion

Just as ethical problems are embedded in technical problems, an engineer's ethical competence must be integrated into their technical competence. To be both competent and ethical, an engineer must possess a keen sense of right and wrong; this ensures that their decisions are anchored in strong and well-informed moral convictions. This foundation of conviction should be accompanied by the virtue of genuine care for others. This ensures that the engineer is driven to prioritize choices that maximize the good for all stakeholders. Striving for fairness and impartiality, the ethical engineer must actively recognize and minimize the effects of bias, if possible, to maintain their objectivity in the decision-making processes. Finally, these moral qualities should be combined with robust technical abilities, enabling the engineer to effectively address and resolve ethical issues with skill and precision. These four characteristics—conviction, care, objectivity, and competence—are essential for the responsible engineer who desires to wisely navigate the landscape of ethical challenges present in their engineering discipline and create a positive impact on society.

Works Cited

Beauchamp, Tom L., and James F. Childress. *Principles of Biomedical Ethics*. 7th ed., Oxford University Press, 2013.

Dorsey, Dale. "Objective Morality, Subjective Morality and the Explanatory Question." *Journal of Ethics & Social Philosophy,* vol. 6, no. 3, 2012, pp. [i]-24. *HeinOnline*, https://heinonline.org/HOL/P?h=hein.journals/jetshy6&i=174.

Estrada, Alan. "Mi expedición al TITANIC parte 1/4 | Alan por el mundo." *YouTube*, uploaded by Alanxelmundo, 6 Aug. 2021, https://www.youtube.com/watch?v=uD5SUDFE6CA. (see timestamp 18:06)

Gino, Moore, and Bazerman. *No Harm, No Foul: The Outcome Bias in Ethical Judgment*. Harvard Business School, Jan. 2008. https://www.hbs.edu/ris/Publication%20Files/08-080_1751f2c7-abe2-402b-9959-1d8190ebf62a.pdf.

Lloyd, Peter, and Jerry Busby. ""Things that went well--no serious injuries or deaths": ethical reasoning in a normal engineering design process." *Science and Engineering Ethics* vol. 9, no. 4, 2003, pp. 503-16. https://doi.org/10.1007/s11948-003-0047-4.

Mohanani, Rahul, Salman, Iflaah, Turhan, Rodríguez, and Ralph. "Cognitive Biases in Software Engineering: A Systematic Mapping Study." *IEEE Transactions on Software Engineering*, vol. 46, no. 12, 1 Dec. 2020, pp. 1318-1339. https://doi.org/10.1109/TSE.2018.2877759.

Morelle, Rebecca, Alison Francis, and Gareth Evans. "Titan Sub CEO Dismissed Safety Warnings as 'Baseless Cries', Emails Show." BBC News, 23 June 2023, https://www.bbc.com/news/world-us-canada-65998914. Accessed 9 Mar. 2025.

Schechner, Sam. "Their Job Is to Push Computers Toward AI Doom." *The Wall Street Journal*, 10 Dec. 2024, https://www.wsj.com/tech/ai/ai-safety-testing-red-team-anthropic-1b31b21b?mod=Searchresults_pos2&page=1. Accessed 9 Mar. 2025.

Vallero, Daniel A., and Claudia K. Gunsch. "Applications and Implications of Emerging Biotechnologies in Environmental Engineering." *Journal of Environmental Engineering*, vol. 146, no. 6, 2020, https://doi.org/10.1061/(ASCE)EE.1943-7870.0001676.