

## Character-Based Engineering Virtues

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## abstract

One of the most neglected subjects in engineering education is engineering ethics. The engineering profession has a greater impact on more people every day than any other profession and therefore, the importance of engineering ethics education cannot be understated. Over the years this neglect has garnered some attention; however, engineering ethics education has not been thoroughly addressed or improved. Virtue ethics is one approach to engineering ethics education that helps in character development. Virtues are character traits/habits of the good, which should be the character traits of the ethical engineer. This article examines engineering ethics education through virtue and identifies the major engineering virtues of phronesis, justice, fortitude, and honesty as the “Hallmarks of an Engineer”. Phronesis is practical wisdom, justice is rendering each person that which he/she is due, fortitude is the moral and physical courage to do what is right, and honesty is rendering truth in all endeavors. These virtues are a solid foundation for character formation and form a construct for engineering ethics education. Internalizing these virtues enables engineers to become more ethical and better equipped to deal with ethical challenges of modern society and engineering.

## introduction

Engineering is an important, valued, and trusted profession, whose esteemed position is built upon a close and necessary relationship between society and engineer professionals [1]. Engineering’s trusted position is rooted in the necessity and reliance of society on the works of engineering. Engineering is interwoven into the daily lives of people continuously, twenty-four hours a day, from the moment they arise, to when they sleep. Quite simply, it is impossible for someone not to engage engineering in some manner on a reoccurring basis in today’s modern world. This is a weighty concept for the profession and the practicing engineer. The relationship of engineering and society dictates that engineers operate in good faith to ensure the welfare of society is paramount. As such, engineering ethics are a part of this complex relationship and the education of engineering students should be effective in making them more ethically minded. This paper will set up virtue ethics as a needed approach in engineering ethics education and exams four virtues as the hallmarks of an engineer: phronesis, justice, fortitude and honesty.

## engineering as a valued profession

Engineering is the integrative application of math, science, and initiative to solve complex problems. It is the engineer who takes these tools and develops practical ways to resolve these problems [1]. Without a doubt, man has improved society’s quality of life by employing engineering. The first “engineers” were born through necessity in the crucible of war where fortifications, war machines, housing, latrines, and other challenges required solutions [2]. In a similar vein, engineering as an academic discipline was established in military academies throughout the world: The Academy of Military Engineering (1689), Moscow; The Estates School of Engineering (1707), Prague; The Ecole Polytechnique (1794), Paris and The United States Military Academy (1802), West Point [2]. In the early 19<sup>th</sup> century, US colleges and universities established engineering departments in most major universities. The United States

Military Academy, Rensselaer Polytechnic Institute, Norwich University and Union College were the first US institutions to offer formalized instruction in the art of engineering [3]. These universities produced educated and trained engineers who developed and built the infrastructure for a new and growing nation. By the mid-1800s, most engineers practicing in the civilian sector had been trained at the United States Military Academy and after their military service had ended, they began to practice engineering in the civilian sector of society. These engineers not only had engineering expertise but they also had the military discipline to solve tremendous construction challenges associated with the development and establishment of the infrastructure such as railroads, roads, buildings, sewage, etc. Over the years, engineering expertise became more prominent as demand rose to assist with national expansion [4]. The growth in engineering education continues in the US and abroad, and currently, the US has some of the top engineering programs in the world: Massachusetts Institute of Technology (#4), Stanford University (#9) and University of Southern California (#11) [5].

the need for engineering ethics

The engineering profession helps people and society daily. “A Profession is a disciplined group of individuals who adhere to ethical standards and who hold themselves out as, and are accepted by the public as possessing special knowledge and skills in a widely recognized body of learning derived from research, education and training at a high level, and who are prepared to apply this knowledge and exercise these skills in the interest of others [6].” There is no other profession which effects more people daily than engineering. It is “...a profession that seeks to harness technological advancements to provide solutions for a wide range of social problems... [7].” Most people do not think about engineering as part of almost everything they do; however, when routines are disrupted, public focus can and will shift to engineering. Regardless of these disruptions, the US population holds the engineering profession in high regard. “The Gallup pollsters found Americans put a lot of faith in these professionals who help design dams, bridges, planes, medical devices and many other things that we count on to be safe and reliable [8].” Embedded in this high regard is a tremendous amount of respect and trust. Indeed, the engineering profession has an added responsibility to protect society’s health, safety, and welfare. One is hard pressed to find a profession that has greater a responsibility to the public than engineering. This responsibility bears a heavy burden on the engineer and it cannot be taken lightly.

The engineering profession’s responsibility to society is bolstered and guarded through the practice of proper engineering ethics. Engineering ethics have developed over the years along with engineering professional societies. Professional societies led the way in engineering ethics through the development of ethical codes. These codes establish a baseline of ethical behavior and are used to determine and adjudicate cases where engineers have breached their responsibility to society. It goes without saying that the engineer should be mindful of their decisions, and they should keep the health, welfare, and safety of society as a top priority. However, are ethical codes enough? Can an engineering student really internalize a list of ethical codes through the current pedagogical construct?

In 1985 the American Board for Engineering and Technology (ABET) made engineering ethics part of its criteria for engineering program certification. Additionally, professional ethical codes evolved to include priorities for the health, welfare, and safety of society as their top

concern. Prior to this, codes were more reflective of protecting the profession and the client. To support this move toward protecting society, professional publications began to address engineering ethics in articles and conferences [9]. As engineering ethics education became inculcated into engineering programs, different pedagogical approaches emerged. As much as engineering education is standardized, engineering ethics education pedagogical approaches are not. The National Academy of Engineering conducted a study in 2016 to identify the best engineering ethics approaches. The study revealed that there were numerous approaches to ethics education which varied from simple in class exercises to dedicated engineering ethics courses [10]. The most common approach was the case study. In a general construct, the case study presents a background on the circumstances of the situation (ethical dilemma), how the parties acted and the consequences of the actions. The study also presents a hierarchy of participants so that ethical codes can be applied to the solution [10], [9], [11]. The beauty of this approach is that there is a prescriptive way to approach an ethics class that is familiar to instructors. This approach prepares the engineer for the engineering ethics portion of the fundamentals of engineering exam (FE) and the professional engineering exam (PE). These exams are structured on an obligation hierarchy where the correct answers are based on the priority of obligation in the codes. This approach is an effective way to pass the licensing exams but does nothing to concretely improve ethical behavior/character [12].

character

How character education is taught is not part of this article; however, it is important to address how character can be changed through virtue education. The most effective way to improve a person's character is through virtue education [13]. However, the methods in which to improve a person's character through virtue education is not well codified. The research in this area is mainly found in elementary school classroom settings [14]. A number of approaches have proven to be effective in this arena and include, but are not limited to, character education in subjects, values education, addressing virtue through literature, and moral-dilemmas [15], [16], [17], [18], [14], [19], [13]. The import here is that the research indicates that virtue education achieves more ethically minded students [13].

If focus is placed on virtue to improve the character of our engineers, which virtues should be the ones that "define" the ethically minded engineer? Our focus here should be on the civic virtues. Civic virtues are those standards of behavior that are morally sound and are focused on the relationship between citizens and society. These virtues are those that mark a person as a good and productive member of society. For the engineer, these virtues are those that promote the wellbeing of society above all else. "A civic virtue is a trait that disposes its possessors to contribute to the well-being of the community and enhances their capacity to do so. [20]" These virtues include selfless service where the needs of society outweigh personal needs; active participation in the community or government; willfully doing what is expected by society to keep it running smoothly; and cooperating with other members of society. The civic virtues include but are not limited to phronesis (practical wisdom), courage, honor, humility, integrity, justice, temperance, perseverance, respect, responsibility, self-governance, honesty, and vigilance [21]. Civic virtues are made up of many components that include reason, emotion, discernment, knowledge, judgement, and action [22]. Civic virtues can be viewed as moral virtues in the civic realm. Civic virtues provide a reminder that the scope of the character should not be focused solely on the individual, but rather on the social connections that

inherently arise from the nature of the job of the engineer. Indeed, emphasis on “civic” also provides a certain vocabulary that enables the engineer to maintain a focus that may otherwise be missed. Finally, promoting the importance of civic virtues in the engineer enables the engineer to intentionally cultivate active, informed and responsible actions of good character [22].

virtue labeling

Although the importance of aligning certain virtues with the profession of engineering is debatable, the alignment of virtues with engineering creates a synergistic effect and a sense of belonging. The alignment of certain virtues also helps in defining who engineers are and how they are expected to act. Characterizing a group by certain virtues is not new. For example on 26 January 1964, General Douglas MacArthur celebrated his 84<sup>th</sup> birthday with the Corps of Cadets. He gave extemporaneous remarks in which he discussed the “*Hallmarks of the West Point Graduate*”. These hallmarks are as relevant today as when they were spoken. “Tolerance, Balance, Intelligence, Courage. These should be the hallmarks of every graduate of the Military Academy at West Point. [23]” MacArthur is describing the virtues he sees as foundational to the West Point graduate. As Superintendent, MacArthur was instrumental in establishing the first codified honor code at West Point. He saw that all the hard work that went into making a good military officer falls short if the character of the individual is not likewise developed. As he describes each, his words are clear, concise, and powerful. “[T]olerance, not to debase nor deprive those from whom one may differ by character of custom, by race or color of distinction. ...[B]alance, a sense of proportion and ability to put first things first. A realization that there is a time and a place for everything but a recognition of the old maxim 'nothing too much' - what the Ancients meant by the 'golden mean'. ...[I]ntelligence, rather than sentiment or emotion. Sentimentalism has muddled many problems, has settled none. Intellect is man's only hope for improvement over his present state. ...[C]ourage, moral courage - the courage of one's convictions - the courage to see a thing through [23].”

These four virtues of which MacArthur spoke, are actually the cardinal virtues of prudence (disposition of right reason about doing something); justice (firm disposition - a person's inherent qualities of mind and character - to give to another what is his/her due); temperance (disposition of the desiring emotions so as to remain properly ordered to the good, to pursue the honorable good); and fortitude (disposition to remain steadfast to the good in danger of death or other threats) [24]. The cardinal virtues comprise a set of four fundamental virtues found in the writings of Plato and others. These virtues are derived from Plato's *Republic* Book IV in which he describes the faculties of man aligned with the characteristics of a good functioning city. These characteristics of a good city are the four cardinal virtues and are required for the virtuous man. “Cardinal” comes from the Latin word for ‘hinge’ - a door relies totally on the hinge to make it work and similarly, a person relies on the four cardinal virtues in order for him/her to lead a flourishing life. In the case of the cardinal virtues, these are the foundational virtues required for a virtuous life [24]. MacArthur has aligned the character of the West Point Army officer with that of the cardinal virtues. The “Hallmarks of a West Pointer” seems very catchy but in this succinct title, there is great meaning that is understood by the West Point graduate and society. MacArthur makes a very compelling case for the Hallmarks of a West Pointer. So why not for the engineer? What are the hallmarks of an engineer?

## the hallmarks of an engineer

When considering the characteristics that are desirable in an engineer, it is appropriate that we look to virtue to define the engineer. The doctrine of virtue is a doctrine of obligation which is fitting for the engineer and his/her obligation to society. Defining a hallmark for our purposes here is synonymous with meta-virtue. A meta-virtue is a virtue that provides oversight and integration of other virtues. When considering which virtues are “hallmarks of an engineer” there are several virtues that readily come to mind. Intelligent, competent, thorough, are a few that stand out; however, if it is a “hallmark” it must provide more than a good characteristic. For example, being thorough in your work is a good trait and something that employers want in their engineers. But being thorough is limited to being thorough. It does not extend its influence on the control of other virtues. Therefore, after careful consideration, analysis and thought, it is proposed that the hallmarks of an engineer are the virtues of phronesis, justice, courage and honesty.

## phronesis

A person who has acquired the right moral traits needs to gradually develop the intellectual virtue of phronesis to guide their decision process [25]. Phronesis is “...the capacity of knowing and enacting the right course of (moral) action through a process of identifying and deliberating between competing values, emotions and alternatives [25].” It is a meta-virtue that guides and deliberates between the moral virtues. We all have different sets of virtues and at times these virtues will come in conflict with one another. We need phronesis to intervene and provide a solution to the conflict [25]. Phronesis is not a virtue that can be formed through habitation. To the contrary, phronesis comes because of a life lived well focused on the virtues. Aristotle, in *Nicomachean Ethics*, states that one cannot find the truly virtuous person among the youth [26]. Indeed, a young person seeking virtue must practice through habitation to become virtuous. This takes time. However, phronesis is built upon life experience and the practice of virtue. Phronesis “...is necessary for the possession of other virtues, and which enables its possessor to navigate through difficult moral situations [25].” Specifically, phronesis provides a constitutive function in that it enables the engineer to perceive the salient ethical points of a situation and a requisite response. For example, an engineer can perceive what may be required in a certain circumstance and know that courage is required because the ethical situation is extremely precarious. Additionally, phronesis has an integrative function especially when different ethical considerations or virtues are in conflict. Imagine a situation where a minor design flaw, which has an astronomically small probability of causing damage (~0%), is identified just after the construction of a multi-story building. The building is still under the contractor’s warranty and addressing this flaw will cost the construction company quite a bit of money to fix. In a situation like this, it might be unclear how to proceed. Regardless, it is the person, who has phronesis, that is best suited to weigh the considerations in a method that generates concern for everyone and to integrate these considerations in a way that is valuable to everyone [25]. This is exactly what we need in our engineers when it comes to ethical decision making. Navigating through difficult moral situations requires much more than what our current ethical codes provide.

## justice

Justice is a virtue of character and helps to regulate the relationships with others. There are three fundamental structures of justice. First, there is the relationship between individuals; second, the relationship between society to the individual; and third, the relationship between the individual to society [27]. These three relational constructs correspond to the three forms of justice: mutually exchanged justice (individual to individual); ministering justice (the community to the individual); and legal justice (individual to society) [27]. The analysis of these three versions is beyond the scope of this article; however, there is the common thread of indebtedness which corresponds to the three different relationships. For the purpose of this article, the focus here is the engineer's relationship with society and with his/her fellow professionals. Justice, in these relationships, comes in the form of obligation/indebtedness. For the engineer, it is a character quality which obligates one to observe and uphold the laws and rules of society [28]. This aligns with the ethical codes established by professional engineering societies, where engineering conduct must follow certain guidelines which are not only ethical but legal as well. Justice also perfects the will and inclines it to render what belongs to each. By practicing justice, the engineer will over time be able to discern how to employ the other virtues so they align with the providing each their due. Over time, justice will obligate the engineer to conduct themselves in such a way that achieving it will become second nature. Giving a person their due requires reflection beyond the self and places one in their figurative shoes. If one does that, the justice usually becomes obvious. For example, you design a house and provide an estimate. After winning the bid to construct the house, you realize that some things came in cheaper than expected. No one else knows, but justice dictates that you owe the difference to the owners. Justice is something everyone wants and ought to have. Justice regulates other virtues and is the first virtue of the institution. Being just is to recognize and treat everyone according to their human dignity. Additionally, justice is associated with a social construct where any external act performed by a person has an associated social consequence. Likewise, society is indebted to the engineer for using his/her expertise to improve the overall quality of life of those that are part of the community.

## fortitude

Fortitude is the ability to face something that scares us and provides us strength in the face of adversity. It is the virtue that underpins and supports all the other virtues [29]. It is a virtue that is universally admired and very difficult to achieve. Fortitude comes third in our hallmarks of an engineer in that it underpins/supports both phronesis and justice. In our construct, fortitude is not achieved if a person does not exercise phronesis and justice [27]. Phronesis informs fortitude in that a person makes a rational decision based on careful thought and consideration. Likewise, without a "just cause" there is no fortitude. A person does not necessarily risk his/her life to mortal danger unless it is to maintain justice [27]. Fortitude comes in the form of physical and moral courage. Ethical engineers need the moral courage to face difficult decisions in the face of very challenging circumstances. For example the courage to address inaccurate or incorrect engineering decisions on design or construction, which might imperil a company's reputation or financial standing, is an exceptionally difficult thing to do, especially when it may cost the engineer his/her job. However, when faced with these types of challenges, the employment of the virtues of phronesis and justice, if rendered as part of the engineer's character, will make this choice easier from the perspective that phronesis and justice will

obligate the engineer to act with fortitude and face this challenge. Courage will assist the engineer to face the challenges in carrying through what needs to be done. This is what we ought to expect in our ethical engineers.

## honesty

Honesty dictates one not to lie, steal or deceive anyone by any means. It is a virtue and an excellence of character which "...promotes trust, fosters healthy relationships, strengthens organisations, and societies, and prevents harm [30]." It is extremely broad but impactful and requires courage. Honest behavior is strongly tied to how a person views the world. The importance of honesty as a virtue cannot be overstated; however, it is a virtue that has been neglected as an academic topic for several decades [31]. Honesty consists of five aspects: truthfulness (being disposed to reliably tell the truth), being respectful of property (being disposed to reliably respect the property of others), proper compliance (being disposed to reliably follow the relevant rules), fidelity to promises (being disposed to reliably keep reasonable promises), and forthrightness (being disposed to reliably give a complete presentation of the facts) [31]. To tell the truth, respecting property, complying to governmental rules and standards, proper compliance, fidelity to promises and forthrightness are what we expect from our engineers.

## conclusion

Engineering is a valued profession that has the esteem and trust of society. With such confidence and respect society expects the engineering profession to produce top quality engineers. With this respect and expectation, it is imperative for engineers to be ethical. Failings of current academic approaches to engineering ethics indicate that a different approach is necessary. The most effective way to achieve more ethically minded engineers is through character development via virtue education. Virtues are excellences of character and define the engineer. MacArthur understood the importance of character development of future Army officers graduating from the United States Military Academy, West Point and identified the Hallmarks of a West Pointer: intelligence, tolerance, balance, and courage. Taking a cue from MacArthur's comments and careful study, this article proposes the hallmarks of an engineer to be phronesis, justice, fortitude, and honesty. These four virtues are selected for their worth in guiding the engineer. It is hoped that this article provides context and additional relevance for guiding the engineer profession in selecting these hallmarks or starting the dialog to embrace them partially and select more applicable virtues.

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