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# Revamping Engineering Ethics Education

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**Abstract:** One of the most important components of the engineering profession is also the most overlooked subjects of an engineering education: engineering ethics. This research looks at engineering ethics education through character development education focused on virtue. The engineering profession has a greater daily impact on the average American than any other profession. Therefore, the engineering ethics education component of an engineering curriculum should not be overlooked. However, the current engineering ethics education pedagogical approaches are severely lacking and need attention. Properly teaching engineering ethics so that there is an impact on student character requires a more committed approach. The proposed character education construction lays the foundation of good character, based in virtue, which will guide the engineer in future ethical challenges. A virtue education baseline enables the engineer to navigate difficult engineering ethical conflicts. Internalizing the virtuous life, provides a more ethical engineer who is better equipped to perceive ethical challenges and then act according to a virtue-based understanding of the right action to a given circumstance. Evidence is lacking which substantiates the effectiveness of this approach; however, evidence does suggest character education results in more civic and moral centric students.

*Keywords:* Character Education, Ethics, Engineering Ethics, Pedagogy, Virtue

## 1. Introduction

The engineering profession is one of service to society, where the safety and well-being of society is paramount. In turn, society holds the profession in high regard and trust (Clemence, 2020). It can be said that engineers and engineering impact everyone every day. From the roads we drive on to the dwellings we live in, engineering is around us in all that we do; however, most people do not consider the impact of engineering and take it for granted that "the engineering" will always work and never fail them. Implied in the relationship of society and the engineering profession, is ethical conduct. It is important that the engineering profession does not lose the trust of society. Therefore, the profession must ensure that institutions produce competent engineers of good character who embrace proper ethics. As we look forward, we have tremendous challenges that will affect future engineers. Greater population growth and technological advances are placing increased pressures on the engineer. Our academic institutions are adjusting curriculums to meet these challenges; however, in the area of "engineering ethics", not much has changed and we continue to pursue engineering ethics in less than effective ways. Consideration to resetting engineering ethics education is warranted. This paper provides a methodological foundation to a new way to address engineering ethics education.

In the 1800's, engineers played a critical role in helping build the nation; however, the 'profession' of engineering was in its infancy. As the nation grew, there were numerous major engineering structural failures that took hundreds of lives and shocked the nation. The Tay Bridge collapse (Lumley, 2013), the Ashtabula train bridge disaster (Corts, 2003), and the Quebec Bridge (Middleton, 2001) are a few of the more well-known and studied events. Each of these examples resulted from unethical behavior on the part of engineers. The silver lining to these tragedies is that they led to development of ethical codes within professional engineering organizations. The first of these codes were established jointly in 1912 by the Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Society of Civil Engineers and developed the first US codes of engineering ethics (Layton, 1986). Initially, the codes focused more on business practices and the obligation to clients and employers (McDonald, 2022). In 1974, the Engineers' Council for Professional Development (ECPD) shifted focus to public health, safety, and welfare (Harris, Davis, Pritchard, & Rabins, 1996). Engineering ethics as a subject of study began to develop in the engineering curriculum as several well publicized disasters added emphasis to this area (Harris,

Davis, Pritchard, & Rabins, 1996). Finally, in 1985, the American Board for Engineering and Technology (ABET), solidified the importance of engineering ethics by requiring engineering programs to add engineering ethics into their curriculum.

As engineering programs developed curriculum to meet the requirements of ABET, different pedagogical approaches to engineering ethics education were tried with some success; however, engineering ethics overall has limited exposure in programs and is pushed to the periphery of engineering education (McDonald, 2022). A study conducted by the National Academy of Engineering looked across the educational landscape to try to find the best approaches to engineering ethics education. The study found that 1) there was no codified methodology to teaching engineering ethics (techniques ranged from short activities used in engineering courses to multiyear courses of study) and 2) the most prevalent practice was a case study approach (National Academy of Engineering, 2016). There is support for the case study approach as the most effective means of teaching engineering ethics and it is a tested pedagogical approach with which many instructors are comfortable (Harris, Davis, Pritchard, & Rabins, 1996), (Herkert, 2000). In another context, the fundamentals of engineering exam (FEE) provides a hierarchical approach to solving FEE questions where obligations to various groups (society, profession, individual, etc) are prioritized with correct answers aligning with the ethical code hierarchical structure (McDonald, 2022). Some programs use professional engineering organizations student chapters as a method to involve students in various community and professional activities. It is believed that students could internalize ethical behavior through involvement in these activities (Schmidt, 2014). In many instances, ethical courses become another requirement to pass to obtain a degree.

Engineering ethics, for most engineers, are linked to the professional codes identified by a particular field of engineering and can be categorized as duties and dilemmas. The engineer can readily identify, through these codes, the duties associated within the professional branch of engineering; however, there is a struggle with how to apply the ethical codes/duties to specific dilemmas. The codes are found on webpages and are a good. For example, the National Society of Professional Engineers (NSPE) code of ethics has six fundamental cannons, five rules or practice, and nine professional obligations with several subcategories associated with each category (NSPE, 2022). This seems very complicated and somewhat difficult to understand considering the level of ethics training provided to engineers in college. To add to the already long list of ethical codes from the NSPE, there is an additional code of ethics for each engineering field. For example, engineering management has a code of ethics from the American Society for Engineering Management (ASEM, 2022). This code of ethics consists of three fundamental principles and seven fundamental cannons. These codes are worthy attempts to provide guidance and provide a baseline of expected ethical behavior. These are deontological (duty based ethical theory that judges an action as right or wrong based on series of rules rather than based on consequences of the action) based codes and do not necessarily motivate the engineer to internalize them (McDonald, 2022). When dealing with codes and rules, there is a limit to what they can cover. There will be gaps which will leave the engineer to rely on their own judgement.

We want engineers to rely on their own judgement because the nature of reality will leave the engineering in a situation that is not covered by a rule or code. Good engineering judgement is precisely what we are looking for in our engineers. A good ethical engineer is the virtuous engineer. "The genuinely virtuous agent however acts on the basis of a true and rational judgment (MacIntyre, 1981)." It should be the goal to have engineers who can perceive ethical dilemmas and be able to rely on their own judgement versus an engineer who must refer to list of codes that may or may not provide an adequate reliable resource (McDonald, 2022). "Such choices demand judgement and the exercise of the virtues requires therefore a capacity to judge and to do the right thing in the right place at the right time in the right way (MacIntyre, 1981)." Our current engineering ethics education fails to provide an avenue for internalization of ethical behavior.

## 2. Engineering Virtue Ethics

We are at a crossroads of sorts. What is the intent of teaching engineering ethics? Is it to make engineers aware of ethical codes and where to find them in their preparation for the FEE or other exams? Or do we want engineers to internalize good ethical conduct in their practice of engineer. I suspect, we want the latter. As previously stated, the current pedagogical approach provides engineers an awareness of the ethical engineer codes and where to find them. We should aim at producing engineers who have internalized the good character and will have ethical judgement in their practice of engineering. Why focus on the character? Because character is tied to the behavior of an individual and is manifested in how they act (McDonald, 2022). Character is defined as "…the ethical estimate of an individual…[and]…provides the structure of internal law that governs inner thoughts and volitions subject to the agent's control under jurisdiction of conscience (Baumrind, 1998)." To affect the character is to effect behavior. For us, we want to affect the behavior of engineers toward good engineering ethics.

What we need to achieve through our engineering ethics education are engineers who internalize the engineering ethical codes in the practice of engineering and act upon complex ethical situations in ways that achieve engineering standards of excellence which are appropriate to our standards of practice (McDonald, 2022). These are the internal goods of engineering. Alasdair MacIntyre describes these goods and practices in the following:

> By a 'practice' I am going to mean any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of, that form of activity, with the result that human powers to achieve excellence, and human conception of the ends and good involve, are systematically extended (MacIntyre, 1981).

Engineering falls into Macintyre's practice definition. What is critical here is that virtue is required to excel in a practice. Virtue becomes that mechanism to guide the engineer through ethical situations and achieve the internal goods of practicing engineering (McDonald, 2022).

Virtue in the practice of engineering is not a new topic. There are several articles written over the years which discuss and analyze the virtue and engineering; however, there is limited work in virtue or character education as the means to educate engineers in engineering ethics (McDonald, 2022). Jon Schmidt makes a compelling argument for virtue ethics to educate engineers (Schmidt, 2014). His main point is that virtues "…are identified within a specific social practice in light of the internal goods that are unique to it (Schmidt, 2014)." He develops a framework for virtue ethics in engineering and applies a virtue ethics approach to engineering ethics. His virtuous engineering is broken into three categories: the "what", the "how" and the "why". The "what" of engineering is "…the assessment, management and communication of risk (Schmidt, 2014)"; the "how" of engineering is practical judgment while exercising objectivity, care, and honesty; and the "why" of engineering is "…to enhance the material well-being of all people… (Schmidt, 2014)" by employing "…safety, sustainability and efficiency (Schmidt, 2014)." He further describes the virtuous engineer as:

> Virtuous Engineers assert their responsibility for engaging in a combined human performance that involves the exercise of practical judgement to enhance the material well-being of all people by achieving safety, sustainability and efficiency while exhibiting objectivity, care and honesty in assessing, managing and communicating risk (Schmidt, 2014).

This description is inspirational and leads the engineer to see something greater than just the practice of engineering. In this definition the engineer is serving something greater than himself. To the contrary, ethical codes are focused on a prevention and are prohibitive in nature (Harris, The Good Engineer: Giving Virtue its Dues in Engineering Ethics, 2008). By taking the ethical codes approach, we are limiting the intent of engineering ethics. The preventive ethical approach cannot inspire the engineer to promote human welfare and cannot cover everything experienced in professional life. The professional life of the engineer has an internal motivational element to it that requires more than prohibitive codes (Harris, The Good Engineer: Giving Virtue its Dues in Engineering Ethics, 2008). It motivates one to exemplary behavior that cannot be garnered through rules-based behavior (McDonald, 2022). Virtue is the necessary mechanism to help us realize our goal of good ethical engineers.

## 3. Character Education

Accepting the argument that virtue is the mechanism which will help us achieve ethical engineers, it is necessary to look at character education since character is tied to virtue. Character education then becomes the construct to build our engineering ethics education. First, we should consider some challenges associated with changing engineering ethics education. Teaching engineering ethics through a character education construct will require hard work. Also, character education pedagogical approaches are not fully codified. Character education research has provided several effective approaches; however, these are mainly children studies in classroom settings in primary and secondary schooling (Berkowitz & Bier, What Works in Character Education, 2007). Aligning values with certain character traits, teaching character through curriculum subjects, values education, teaching virtue through literature, moral-dilemma tests and so on are all examples of character education approaches at the primary level (McDonald, 2022), (Arthur, Harrison, Carr, Kristjansson, & Davison, 2014), (Arthur, Kristjansson, Harrison, Wouter, & Wright, 2016), (Berkowitz, What Works in Values Education, 2011), (Berkowitz & Fekula, Educating for Character, Nov 1, 1999), (Berkowitz & Bier, What Works in Character Education, 2007), (Hart, Pike, & Oliveira, 2020), (Kristjansson, 2015) . Although the resulting research has produced different successful pedagogical approaches (Berkowitz & Bier, What Works in Character Education, 2007), the most successful are those that focus on virtue education to improve character and achieve more civic and ethically minded students (Kristjansson, 2015).

It is difficult to find college level programs focused on character development. Most college level character education can be broken down into formal, judicious, and guided learning processes (Ray & Montgomery, 2006), where formal learning is the "traditional" classroom experience; judicious learning utilizes situational case studies involving "justice" to promote character education; and guided learning uses mentors or role models as important integrated pieces to character education (McDonald, 2022), (Ray & Montgomery, 2006). Most colleges provide various character or leadership instruction that have

components of formal, judicious, or guided learning but, few have an integrated character development program (McDonald, 2022). As a method of developing student character, a good number of colleges have focused on establishing leadership development programs or community volunteer service centers. Through these programs, it is assumed that students who actively participate will develop their character in a positive way (Astin & Antonio, Nov-Dec 2000). Authors Berkowitz and Fekula proposed a college level character educational model that is broken into five components: teaching about character; displaying character; demanding character; apprenticeship; and reflecting on character (Berkowitz & Fekula, Educating for Character, Nov 1, 1999). This model supports a pedagogical approach which provides a foundation of understanding through education, mentorship, standards, and reflection. Reflection is an important component that allows the student to assess and adjust their behavior. As successful as Berkowitz and Fekula's approach might be, most colleges/universities look to the 'participation' approach as noted previously (Berkowitz & Fekula, Educating for Character, Nov 1, 1999).

## 4. A Pedagogical Approach

Section 4 is from a previous work completed by the author with minor adjustments (McDonald, 2022). Virtue education is difficult to accomplish if one wishes to change an individual into a more virtuous, and by default, ethical engineer. You can teach someone about virtue, but you cannot teach them to be virtuous; however, they can catch it (Aristotle, 1934). It requires the person to want to be virtuous. Therefore, As mentioned, there are effective approaches at the primary school level; however, character education research at the college level is limited. In this section, elements for implementing engineering virtue ethics are proposed to provide a construct from which institutions and engineering programs could build a specific approach to achieving virtuous engineering graduates. These elements are selected based upon research and implementation experience and have historically been successful (Anderson & McDonald, 2019) (Berkowitz & Bier, What Works in Character Education, 2007) (Berkowitz & Fekula, Educating for Character, Nov 1, 1999). The list of elements has not necessarily been grouped together before; however, this list includes proven pedagogical approaches and when combined, are much more effective than if implemented separately. They build upon each other and gather strength. These are not set in any order of preference or importance; however, to be effective, all components should be implemented in some manner (McDonald, 2022).

### 4.1 Assign Institutional Value

Institutional value is defined as the college recognition of engineer virtue education as important through assigning academic value to any courses associated with education. If an institution is not willing to invest academic value to engineer virtue education than one cannot expect engineering students to take this seriously (Anderson & McDonald, 2019). Additionally, institutional value is inculcating character/virtue as part of the overall "theme" of the institution. This can be seen in institution mission statements, other extracurricular programs, etc. In addition, engineering programs will place value on engineer virtue ethics as well. Grades and such will be assessed based on engineer virtue education classes and engineering programs should make character/virtue a part of their overall mission statement. Character/virtue should be inculcated into the classroom beyond your standard courses in virtue. A holistic program should be embraced by the engineering faculty (McDonald, 2022).

### 4.2 Foster Desire

While assigning institutional value is important, equally important is cultivating an environment where students can develop a desire to be virtuous (Anderson & McDonald, 2019). This is a very heavy task; however, if the virtuous engineer is the exemplar of what the institution promotes as the ultimate achievement of an engineer, then the burden can be shifted. There are numerous reasons why people seek an engineering degree: internal drive to build something, desire to solve problems, help society, job security, etc. All these internal drives are worthy and justifiably should be praised. Most engineering students are hard workers, focused and disciplined. These character traits could be leveraged to turn some of that drive toward virtue. One method would be to challenge new engineering students to achieve the ultimate engineer exemplar. Some of these students would seek the challenge. It is not to say that this would be highly effective; however, it does point out that early exposure to the exemplar the challenge would put this concept into the minds of the engineering students at an early stage in their engineering education (McDonald, 2022).

### 4.3 Teach About Virtue

As Anderson and McDonald and Berkowitz and Fekula rightly point out, you must teach virtue for students to develop a baseline understanding as well as an awareness of virtue (Anderson & McDonald, 2019) (Berkowitz & Fekula, Educating for

Character, Nov 1, 1999). A basic virtue course should be part of the required engineering curriculum. This course would provide initial exposure for the engineer of the basic understanding and language of virtue. The course should be tailored to the engineering audience to address questions and construct class examples that are engineer focused. This initial course should be required in the freshman or sophomore year and would be a requirement in the engineering curriculum. Likewise, to enhance this teaching, virtue ethics should be brought into the normal engineering course across the curriculum to enhance the awareness of virtue throughout the college experience of the engineering student (McDonald, 2022).

### 4.4 Mentor

An intellectual baseline is essential for the engineering student; however, virtue is "caught" not taught (Anderson & McDonald, 2019). The most effective way to "catch" virtue is to provide the student mentorship; however, the sheer number of students in engineering programs would overwhelm the faculty if this requirement was placed solely on their shoulders. One method could be to take senior level students and align them with freshmen in a student mentorship program. Obviously, this would not be the optimal solution; however, it would provide a level of mentorship that would make some difference. The mentors would be provided some training in mentorship and would have a limited amount of responsibility as determined by the engineering program. As stated, the success here would be tempered due to the experience of the mentors; however, this would be countered by the fact that this aspect of the overall construct would have the added benefit of increasing awareness of engineering virtue ethics as well as giving the mentors more practical experience (McDonald, 2022).

### 4.5 Practice

Students learn more when they practice or are challenged. Active learning environments are more effective for student learning and provide an experience to help solidify concepts through engagement (Lowman, 1995). One method in this realm of practice is experiential learning. Experiential learning is learning through experience which can take several different forms. Student benefits include but not limited to ability to grasp concepts, be more creative, have time to reflect, make mistakes as well as improve attitudes toward learning (Kolb, 2015). These experiential learning events can range from athletic competition to practical classroom exercises and can elicit experiences which test the character of the student (Berkowitz & Fekula, Educating for Character, Nov 1, 1999). With the focus on virtue, dilemma narratives aligned with actual activities can be very impactful to the student. Another way to seek the testing of virtue can also include adventure type events where students are placed in difficult team situations such as the military's leadership reaction course. Most institutions will have ROTC units available where coordination and cooperation can leverage these types of events at minimal cost and impact. Likewise, it can establish a closer bond with the students going through ROTC program (McDonald, 2022).

### 4.6 Enforcement and Rehabilitation

If anything is to be of value, it must hold value with the group upon which it sits. If engineering virtue ethics is to have an impact, it must have value within the engineering community. Here is where codes can be effective in providing some boundaries of behavior. Honor codes are examples where institutions place value on certain behaviors. There are approximately 69 US institutions that currently have honor codes which stipulate students will refrain from cheating, stealing, and lying (Academic Honor Code, 2021). They are also required to turn in students who break the honor code. The enforcement of these codes vary from institution to institution but the intent here is to place value on virtues/character traits associated with the values of the institution. Enforcement should have a necessary component of rehabilitation. Without rehabilitation, we lose an essential aspect of virtue. Rehabilitation provides the greatest gift to a young student who makes a mistake or breaches the code – experience. How many of us have done things we regret and if we were caught, how thankful we were if we were forgiven? It was a transformational learning lesson that enabled us to become something better. It is necessary to enforce the engineering virtue ethics of the engineering program, but equally important is the rehabilitation of the student who is caught violating the established code (McDonald, 2022).

### 4.7 Reflection

Finally, reflection allows the student to ingest all the information and experiences as it relates to others and himself. By reflecting, students gain a richer experience and learn. It allows the student to review their skills and how effective or ineffective they are and where and what they need to do to improve. It is hoped that through reflection, they will develop into more creative and resourceful thinkers. For our purposes here, reflection should be initially a set activity where younger

students are guided through deeper thought. As they mature, these students will begin to use reflection to their advantage and hopefully become deeper thinkers (McDonald, 2022).

### 4.8 Element Interaction

The seven elements, as mentioned earlier, are proven pedagogical approaches in character education. Table 1 illustrates the basic relationship between these elements and the primary educational cause/effect on the individual. For example, element 2 – Foster Desire, the primary cause or effect is an internal motivation by the individual. Trying to make an individual desire something is a very difficult task and comes down to the free will of the individual. In addition to the specifics identified in the Foster Desire paragraph above, the other elements have a contributing effect on the success of element 2. In the case of element 2, all other elements contribute to developing a desire in the individual to "want to" be virtuous (McDonald, 2022).

Table 1. Element Interaction (McDonald, 2022)

| Element | | Primary Cause | Contributing Element |
|---|---|---|---|
| 1 | Assign Institutional Value | External | 3, 6 |
| 2 | Foster Desire | Internal | 1, 3, 4, 5, 6, 7 |
| 3 | Teach About Virtue | External | 4, 5, 6, 7 |
| 4 | Mentor | External / Internal | 1, 2, 3, 5, 6, 7 |
| 5 | Practice | Internal | 3, 6, 7 |
| 6 | Enforcement and Rehabilitation | External / Internal | 1, 2, 3, 4, 5, 7 |
| 7 | Reflection | Internal | 2, 3, 4, 5, 6 |

## 5. Conclusion

The engineering profession is one of the most trusted professions and has earned the respect and confidence of society. As such, the engineering profession has an inherent responsibility in promoting and protecting the health and welfare of society in all endeavors. The practice of good engineering ethics by engineers is integral part of the engineering profession; however, there are challenges with the current approach to engineering ethics education. A possible solution to these challenges is virtue and character development education. Character development education is a new and effective approach to developing ethical engineers, but it requires a tremendous effort. The pedagogical approach to achieve a successful result, includes assigning institutional value, fostering a desire, teaching virtue, mentoring, practicing virtue, enforcement, rehabilitation, and reflection. If developed, the result will be better and more ethical engineers.

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