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Rogue Engineering: Teaching Frankenstein as a Parable of (Un)ethical Engineering Practice

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Abstract

Mary Shelley's novel *Frankenstein* is widely regarded as a foundational work of early science fiction that cautions against misguided and unethical science and engineering. As such, the novel should be poised to help engineering undergraduates cultivate moral imagination and a commitment to socially responsible techno-science. However, despite recent critical editions of the novel that highlight its relevance for scientists and engineers, some instructors have faced difficulties successfully integrating the novel into an undergraduate engineering curriculum, and students have struggled to appreciate its value to their ethical formation as engineering professionals. Nevertheless, the novel's potential to address ethical aspects of engineering practice calls for further attempts at integrating it into engineering education. In particular, the archetypal figure of Victor Frankenstein offers students a model of a negative "possible self" that cautions against rogue engineering practices. The paper analyzes themes from Shelley's novel as they were used in courses in science, technology, and society (STS) to foster ethical reflection on the perils of practicing irresponsible, presumptuous, unaccountable, and biased techno-science.

Introduction

Mary Shelley's novel *Frankenstein* is widely regarded as a foundational work of early science fiction that cautions against misguided and unethical science and engineering. As such, the novel should be poised to help engineering undergraduates cultivate moral imagination and a commitment to socially responsible techno-science. Along this line, a recent critical edition of the novel published in celebration of its bicentennial highlights its relevance for fostering ethical formation among scientists and engineers [1]. Likewise, recent scholarship draws attention to *Frankenstein*'s role in engendering critical reflection among scientists about social and ethical aspects of their work [2]. Despite, however, the novel's potential to speak to ethical dimensions of scientific and engineering practice, some instructors have encountered difficulties successfully integrating Frankenstein into an undergraduate engineering curriculum; and students have struggled to appreciate the novel's value to their professional development as engineers [3].

Nevertheless, the novel's capacity to address ethical aspects of engineering practice, both historical and contemporary, calls for further attempts at integrating it into engineering education. The archetypal figure of Victor Frankenstein presents students with a negative role model or possible self that can deter them from developing unethical professional identities and practices [3], [4]. As Victor himself urges in an aside to his audience, "Learn from me, if not by my precepts, at least by my example, how dangerous is the acquirement of knowledge and . . . he who aspires to become greater than his nature will allow" [5]. As a cautionary tale of science fiction, Mary Shelley's *Frankenstein* provides a constructive framework for (un)ethical engineering practice that underscores the perils of irresponsible, presumptuous, unaccountable, and biased techno-scientific innovation. In what follows, I analyze these themes from Shelley's novel as they were discussed in undergraduate courses in science, technology, and society (STS). The analysis that follows offers resources for engineering instructors and students alike

interested in drawing on the humanities to foster ethical reflection and professional identity formation oriented toward socially responsible engineering practice.

Frankenstein: Ethics for Scientists and Engineers

The recent bicentennial of Mary Shelley's *Frankenstein* in 2018 has generated renewed interest in the novel's capacity to prompt ethical reflection about the practice of contemporary techno-science and engineering. For example, in 2017 David H. Guston et al. published a new critical edition of Shelley's novel annotated, as the sub-title indicates, "for scientists, engineers, and creators of all kinds" [1]. The notes and scholarly essays in the new edition draw attention to "social and ethical aspects of scientific creativity raised by. . . [Shelley's] remarkable story" [1]. The editors envision the new annotated edition of the novel as being uniquely situated to address ethical concerns about emerging forms of techno-science. Aimed primarily at "readers with a background or interest in science and engineering," and "STEM students from high school to graduate school" specifically, the editors aim to use *Frankenstein* to explore "fundamental questions of creativity and responsibility" pertaining to controversial forms of techno-science such as "synthetic biology, artificial intelligence, robotics, and climate engineering" [1].

Likewise, researchers have found productive ways of using *Frankenstein* to prompt ethical reflection among professional scientists and engineers. Publishing in the novel's bicentennial year, Peter Nagy et al. conducted a study that examines how the Frankenstein myth has influenced professional identity and ethical formation among techno-scientists working in public research universities in the United States [2]. Those surveyed in the study were all engaged in projects related to emerging technologies, including "genetic engineering, synthetic biology, nanotechnology, robotics, and artificial intelligence" [2]. When asked about their perceptions of the Frankenstein myth and the figure of Victor Frankenstein, the interviewees resonated with positive qualities of Victor Frankenstein such as his creativity, imagination, and passion for advancing scientific knowledge [2]. At the same time, however, they repudiated his arrogance and irresponsibility, as well as his cavalier attitude toward "the social and ethical consequences of his scientific enterprise" [2].

The researchers found that the scientists they interviewed drew on aspects of the Frankenstein myth to construct a professional identity oriented toward values of "transparency, responsibility, and ethical conduct" [2]. In articulating these positive self-conceptions, the interviewees attempted to "distinguish themselves from their unwanted possible selves, the shades of Victor Frankenstein" [2]. Building on psychological research into the notion of possible selves as resources for self-development [4], [6], the study concludes that the figure of Victor Frankenstein offers an "iconic possible self for scientists" that functions to set norms, whether implicit or explicit, regarding "what is deemed desirable and undesirable in scientific behavior" [2].

Mary Shelley's *Frankenstein* has also been used recently in the engineering classroom to help students forge interdisciplinary connections between engineering practice and fields in the humanities, such as ethics. Capitalizing on the bicentennial of Shelley's novel, James Canino and Kendall Teichert, engineering professors at Triune University, developed an introductory mechanical engineering design course that attempted to integrate themes from *Frankenstein* into

robot design projects [3]. The principle aim of the course was to provide a vehicle for students "to experiment with connecting engineering and the humanities" [3]. To facilitate this connection, students were tasked to develop designs for robots that related to themes in Mary Shelley's *Frankenstein*. As they read the novel, students reflected on certain passages they thought could serve as thematic inspiration for robot design concepts. In their reflections, students included a sketch of the concept design along with an explanation of its connection to a particular theme in the novel. After analyzing the students' reflections and the robots they designed, the authors conclude that most student projects only engaged with the novel's themes in "superficial" ways that "lacked depth" [3]. For example, one project featured a robotic snowplow inspired by the kinds of chores the creature performs for the De Lacy family [3].

Further, in a survey given to students about their experience in the course, only 11% of students claimed to have read the entire novel, and many commented that they found the novel neither enjoyable nor relevant for their understanding of engineering [3]. In fact, several students regarded having to read *Frankenstein* as a distraction from other, more valuable forms of learning likely connected to their technical design work [3]. This may be, in part, because there seems to have been very little class discussion of the novel and its relation to engineering design and ethics. Although a humanities professor was brought in to talk about the novel for one class session, 45% of students reported that it had no or negative impact on their engineering education [3]. Nevertheless, when reflecting on their experience reading the novel, 59% of students surveyed admitted that it "expanded their understanding of ethics" [3]. This insight suggests that in another, non-technical learning environment Shelley's novel might provide a productive means for engineering students to reflect on ethical matters pertinent to engineering practice and professional identity formation.

Constructing Possible Selves

The psychological concept of possible selves, developed by Hazel Markus and Paula Nurius, examines how people use both positive and negative imaginations of the self to guide motivation, behavior, and identity construction, including ethical formation [4]. According to the authors, possible selves facilitate self-knowledge informed by "the ideal selves we would very much like to become" as well as "the selves we are afraid of becoming" [4]. As such, possible selves function as "cognitive manifestation[s]" of persistent "goals, aspirations, motives, fears, and threats" and operate as "the essential link between self-concept and motivation" [4].

Importantly, the authors argue that the possible selves people construct, though numerous and varied, are "socially determined and constrained" [4]. Social, cultural, and historical contexts shape the horizons of possibility for self-conception as do "the models, images, and symbols provided by the media" [4]. Further, people often develop conceptions of possible future selves by contrasting their own "thoughts, feelings, characteristics, and behaviors" with "those of salient others" [4]. The concept of possible selves thus offers resources for conceptualizing how engineering undergraduates might construct professional identities in contrast to media depictions of a "salient other," such as Victor Frankenstein, who represents an undesired or feared possible self [2].

To foster this kind of ethical reflection and professional identity formation, I discuss the figure of Victor Frankenstein in two different non-technical undergraduate courses in STS. In what follows, I begin with a brief overview of the two courses and how they engage with Shelley's novel. Then, I summarize several themes drawn from the novel's depiction of Victor Frankenstein that warn against unethical techno-science and that offer a negative model of a possible professional self. With Victor's cautionary example in mind, students can construct contrasting possible selves oriented toward values of socially responsible engineering practice.

Teaching *Frankenstein*

Discussions of Mary Shelley's *Frankenstein* feature prominently in two courses I teach at the University of Virginia, both of which are non-technical engineering courses in STS. The first is a middle-level elective course called "Technology and the Frankenstein Myth." In the first half of the course, students perform a close reading of the novel and identify themes that characterize the Frankenstein myth. The class approaches the novel as a cautionary tale of early science fiction, and discussions center on concerns the narrative raises about unethical scientific and engineering practices. Special attention is given to how the narrative represents the scientist/engineer in the figure of Victor Frankenstein and the practice of rogue techno-science embodied in the creature Victor brings to life.

In the second half of the course, students analyze several films and short stories that allude to and update the Frankenstein myth to address contemporary concerns about emerging forms of techno-science such as eugenics and genetic engineering, cloning, autonomous robots, and artificial intelligence. Among the media discussed are James Whale's *Bride of Frankenstein* (1935), Steven Spielberg's *Jurassic Park* (1993), and Joss Whedon's *Avengers: Age of Ultron* (2015), as well as a selection of Isaac Asimov's robot stories. In addition, students consider how the Frankenstein myth has influenced public discourse about embryo research, genetically modified foods, technologies of de-extinction, and weapons of mass destruction.

Learning assessments include in-class discussions and debates, supported by reading quizzes and written reflections on assigned materials. The course culminates in a short research paper students write that examines how discourses of monstrosity inform public responses to a controversial technology of their choice. Students also compose a pitch for a companion science-fiction story that reflects on the technology's potential social and ethical impacts.

The second course that draws on Shelley's *Frankenstein* is a required first-year course in STS called "Designing for a Sustainable World." The course introduces students to social and ethical aspects of engineering design through a series of class lectures and projects oriented toward sustainability [7]. The lecture meetings provide students with frameworks and examples that equip them intellectually to develop technical designs that facilitate socially responsible and sustainable practices [8]. Meanwhile, a series of class projects students work on together in lab sections culminates in a conceptual design proposal in which they describe a concept for a technology that could help the university community make progress toward the United Nations Sustainable Development Goals.

Two class lectures draw explicitly on Shelley's *Frankenstein*. These lectures discuss the figure of Victor Frankenstein to illustrate the perils of unethical engineering practices that fail to prioritize values of social responsibility and care in technological design. They provide students a negative model of a possible self, as depicted in science fiction, in the hopes of motivating them to develop more ethical professional identities in contrast to Victor Frankenstein.

Below I summarize several of the themes I discuss in these courses related to Victor Frankenstein's misguided and unethical pursuit of techno-science. These themes are summarized in a rhetorical manner similar to how they are presented in class sessions with students. The four themes drawn from Shelley's *Frankenstein* include: irresponsibility, presumption, isolation, and bias. Among the novel's varied themes, these four especially highlight its potential to foster ethical self-reflection and values of socially responsible techno-science among engineering students who, with Victor, have "astonishing . . . power placed within [their] hands" [5].

Victor Frankenstein: A Cautionary Tale

The figure of Victor Frankenstein has long functioned as one of the premier fictional archetypes of the scientist-engineer [2], [9]. His literary legacy casts a long shadow that continues to influence perceptions of techno-science and engineering practice to this day [10]. As a work of pessimistic science-fiction, *Frankenstein* tells a cautionary tale [11]. The novel explores concerns and fears about the practice of techno-science in the early nineteenth century, concerns which continue to resonate today more than two hundred years after its initial publication in 1818. At the heart of the novel's cautionary tale is the figure of Victor Frankenstein. Victor is the young, innovative, and ambitious scientist-engineer who, as a university student, discovers the source of life. Eager to capitalize on this discovery, after months of tireless toil, Victor develops a viable proof of concept, as it were. In his "workshop of filthy creation," he assembles a body from human and animal remains [5]. Then, "on a dreary night of November," while "the rain pattered dismally against the [window] panes," Victor takes up the technical "instruments of life" and infuses an electrical "spark of being" into the creature that brings him to life [5].

What is striking is that the novel itself is framed largely as a narrative told by a slightly older and more chastened Victor about the follies of that undertaking. "Learn from me," Victor urges at one point, "if not by my precepts, at least by my example, how dangerous is the acquirement of knowledge and . . . he who aspires to become greater than his nature will allow" [5]. Throughout the novel, then, Victor tells his tale of woe to caution against doing as he has done. And he hopes that those who listen will, as he says, "deduce an apt moral from my tale" [5]. So, if the novel is a cautionary tale about Victor's misguided practice of techno-science and its awful consequences, what is it warning against? What can be learned about rogue engineering from one of its most fearful archetypes?

Irresponsibility

One of the most salient themes the novel addresses is Victor's profound irresponsibility and neglect of care toward the creature he has made. Victor's example of irresponsible techno-science thus provides engineers with a possible self to avoid in favor of a professional identity oriented toward social responsibility and care. The theme of Victor's irresponsible neglect of

care is related to one of the central questions the narrative poses: what makes the creature monstrous. Although his appearance is hideous from the beginning, and his origin and form are unnatural [12], [13], [14], the creature's actions and motives are not initially threatening or malevolent. In fact, early in the story the creature is portrayed as innocent, even childlike, and he wants to be virtuous. So, what happens to turn his character monstrous? What poisons his soul and fills him with such hatred and murderous rage?

To answer this question, it's helpful to go back to the moment when Victor first animates the creature. There, as Victor watches the creature come to life, his emotional response shifts from one of admiration to disgust. Victor's first reaction is to comment in wonder on the proportionality of the creature's limbs and the beauty of his features. He marvels at "the work of muscles and arteries" visible just beneath the creature's "yellow skin," as well as his "lustrous" and "flowing" black hair and "pearly" white teeth [5]. But then his gaze shifts and fixates on the creature's "watery eyes" and "his shriveled complexion and straight black lips," which formed a "horrid contrast" to the beauty and proportionality he had noted earlier [5]. Reflecting on his changing emotional reaction to the newly animated creature, Victor remarks, "now that I had finished, the beauty of the dream vanished, and breathless horror and disgust filled my heart" [5]. Victor seems to admit here that he had been caught up in a dreamlike state of imaginative self-deception only to awaken to a living nightmare as the reality of what he has done, and the responsibility of care he owes, slowly dawns upon him.

His first response is to abandon the creature and flee his "workshop of filthy creation" to his bedroom, where he paces back in forth in nervous anxiety and dread [5]. And that act of abandonment, of revulsion and painful rejection, has a powerful effect on the creature as the story goes forward [15]. In time, it fills the creature with a deep sadness and a burning anger that disfigures his soul and turns him monstrous. Adding to his misery, every person the creature goes on to encounter repeats Victor's initial act of revulsion and rejection in one form or another. The resulting anguish leads the creature to lash out in destructive and murderous rage, after which he vows to find the man responsible for bringing him into such a world as this.

Several years later, the creature tracks Victor down and confronts him on the icy slopes of the Swiss Alps and levels a damning accusation against him. He says to Victor, "You, my creator, detest and spurn me, thy creature to whom thou art bound" [5]. Then, after accusing Victor of wrongly abandoning him, the creature charges Victor to take responsibility for his well-being and perform the duty of care he had previously neglected. "Do your duty towards me," he demands, "and I will do mine towards you and the rest of mankind" [5]. Scholars of the novel have noticed this theme of failed care, and they've argued that it lies at the heart of Shelley's cautionary tale [16], [17]. What turns the creature's character monstrous, they explain, is Victor's irresponsible failure to show the creature adequate care [16], [17]. "Frankenstein explicates," they contend, "the ethical importance of care. The novel is a parable about the dire consequences of care's absence" [16]. A central question, then, that the novel explores is what happens when we fail to show care to our creations, to someone or something we are responsible for. And one answer the story offers is that it can make them into monsters.

Given the creature's unique composition and origin, the novel invites us to consider the creature's monstrosity in terms of both his human and machine-like qualities. On the one hand,

the creature is made of dead and decaying organic matter. In one sense, then, he's human-like; he's a person. On the other hand, the creature's limbs are assembled like interchangeable parts and animated like those of a machine, with an electrical "spark of being" [5], [18], [19], [20]. So, the creature is both a person who experiences his creator's painful rejection and a technological creation that isn't shown proper care by its designer. This allows the novel to caution against not just how people treat other people but also against how scientist-engineers treat their technological creations. Both are owed a duty of care; and both can suffer from an irresponsible neglect of care [17].

In fact, care ethicists Berenice Fisher and Joan Tronto stress that care can be shown to a "thing" as well as to a "person, or group" [21], [22]. Further, Fisher and Tronto define the ethical practice of care as "everything we do to maintain, continue, and repair our 'world' so that we can live in it as well as possible" [21], [22]. The world, they explain, "includes our bodies, our selves, and our environment" [21], [22]. While the environment certainly encompasses the natural ecosystems we inhabit and share with other organisms, it can also be construed in terms of the technological or built environment replete with the technical artifacts that engineers design and manage.

Frankenstein, then, illustrates what can happen when human creators like Victor Frankenstein neglect their duty of care. If we fail to practice responsible care, we risk turning our technologies against us so that, instead of working to enhance human well-being, they become monstrous and threaten us harm. Whether gene-editing technologies, threat-assessing machine-learning algorithms, microplastic particles in synthetic clothing, or artificially intelligent cars and trucks that can drive themselves – these are all emerging technologies that will need the care of conscientious engineers if they are to work for and not against social good and human well-being.

Presumption

At one point in his story, Victor faults himself for his act of "presumption" and "rash ignorance" that resulted in the animation of the creature [5]. What was presumptuous and rash about his undertakings? And how do these qualities inform the kind of possible self the novel cautions against? There are hints early on as Victor tells of his childhood and upbringing. From a young age he is captivated by "the enticements of science" [5]. "The world," he says, "was to me a secret which I desired to know" [5]. He is impelled by nascent scientific "curiosity" to "learn the hidden laws of nature" [5]. But Victor's approach to the natural world is not guided by what we would recognize as values of sustainability and responsible stewardship. Instead, his scientific interests are fueled by strong, "vehement" passions and a disposition he admits is "sometimes violent" [5]. In fact, the novel portrays Victor's approach to nature as domineering, exploitative, and borderline predatory. He is driven by what he calls "a fervent longing to penetrate the secrets of nature…the physical secrets of the world" [5].

And in time, Victor's desire to discover the source of life and "bestow animation on lifeless matter" becomes obsessive [5]. He revels, as he says, in the "astonishing . . . power placed within my hands" [5]. So, he throws caution to the wind and devotes himself entirely and unrelentingly to his work.

> I pursued my undertaking with unremitting ardour. My cheek had grown pale with study, and my person had become emaciated with confinement. Sometimes, on the very brink of certainty, I failed; yet still I clung to the hope which the next day or the next hour might realise. One secret which I alone possessed was the hope to which I had dedicated myself; and the moon gazed upon my midnight labours, while, with unrelaxed and breathless eagerness, I pursued nature to her hiding-places . . . a resistless, and almost frantic impulse urged me forward; I seemed to have lost all soul or sensation but for this one pursuit . . . [in which] I was thus engaged, heart and soul [5].

The problem, here, is that so fixed is Victor on completing the creature and bringing him to life that he doesn't seem to consider the implications and consequences of his actions. In fact, the few times when he does look ahead to anticipate the effects of his work, he's caught up in self-important delusions of grandeur [23]. He imagines that, after bringing the creature to life, "A new species would bless me as its creator and source; many happy and excellent natures would owe their being to me. No father could claim the gratitude of his child so completely as I should deserve theirs" [5]. This sort of thinking is what a more chastened Victor later condemns as presumptuous and rash. Although in places he gestures toward more altruistic ends for his research, his primary concern seems to be with the gain to his reputation and status it would bring [23]. He seems blithely ignorant of the social consequences of his work or the ethical obligations that would follow from bringing a new creature to life, especially one created in so unconventional a way.

This kind of cavalier attitude can plague the engineering profession: "Move fast and break things" [24]. Pursue innovation for innovation's sake, consequences be damned. Someone else who understood this is Michael Crichton, the author of the novel *Jurassic Park*. In the novel, Crichton draws on themes in Shelley's *Frankenstein* to imagine what might happen were engineers able to use genetic engineering and cloning technologies to bring dinosaurs back from extinction as spectacles in a zoological theme park. At one point in the novel, a scientist named Dr. Ian Malcolm, who has been brought in to observe and evaluate the project, cautions against the kind of rash presumption on display. In fact, he gives it a name: "thintelligence" [25]. Speaking about those who engineered the park's dinosaurs, Dr. Malcolm observes:

> They don't have intelligence. They have what I like to call 'thintelligence.' They see the immediate situation. They think narrowly and they call it being 'focused.' They don't see the surround. They don't see the consequences. That's how you get an island like this. From thintelligent thinking [25].

Although the reference to the term "thintelligence" doesn't appear in the classic 1993 film version of *Jurassic Park* directed by Steven Spielberg, the character of Dr. Malcom, played by Jeff Goldblum in the film, nevertheless expresses a similar concern. "Genetic power is the most awesome force the planet has ever seen," he warns [26]. "But you wield it like a kid that's found his dad's gun. I'll tell you the problem . . . You stood on the shoulders of geniuses to accomplish something as fast as you could . . . Your scientists were so preoccupied with whether or not they could do it, they didn't stop to think if they should" [26].

And that was Victor's mistake: presumption, rash ignorance. "In a fit of enthusiastic madness . . . [of] senseless curiosity," he concedes, "I created a rational creature" [5]. And so, he gives life to something he doesn't fully understand, that has a will of its own, and whose actions he can't control or predict. And in the end, the creature turns on Victor and takes from him everything and everyone he holds dear. So, when engineers are urged to "move fast and break things," to get caught up in the "frantic impulse" to innovate and iterate, the cautionary tale of Victor Frankenstein can give them pause. It can encourage them to slow down, reflect, try to see the "surround," and try to gauge the potential impacts of their technical designs before they take on a life of their own, for better or worse.

Isolation

Another of Victor's problems is isolation. When he arrives at university and eventually discovers the source of life, he isolates himself. He sequesters himself from his fellow students, his professors, his family, and even from the natural world he had so adored as a boy. Victor's example, then, warns against a possible self in social isolation, alone and unaccountable. Having retreated from those around him, Victor throws himself into his work.

> The summer months passed while I was thus engaged, heart and soul, in one pursuit. It was the most beautiful season; never did the fields bestow a more plentiful harvest, or the vines yield a more luxuriant vintage: but my eyes were insensible to the charms of nature. And the same feelings which made me neglect the scenes around me caused me also to forget those friends who were so many miles absent, and whom I had not seen in so long a time. I know my silence disquieted them . . . but I could not tear my thoughts from my employment, loathsome in itself, but which had taken an irresistible hold of my imagination [5].

So, Victor isolates himself even though he remains cognizant of the pain this would inflict on those he cares about. He works tirelessly in secret and seclusion in what he calls his "workshop of filthy creation" [5]. As he pours his life into his work, his physical and mental health begin to deteriorate.

> Winter, spring, and summer passed away during my labours; but I did not watch the blossom or the expanding leaves – sights which before always yielded me supreme delight – so deeply was I engrossed in my occupation. The leaves of that year had withered before my work drew to a close . . . But my enthusiasm was checked by my anxiety . . . Every night I was oppressed by a slow fever, and I became nervous to a most painful degree; the fall of a leaf startled me, and I shunned my fellow creatures as if I had been guilty of a crime. Sometimes I grew alarmed at the wreck I perceived that I had become [5].

There is an interesting parallel that develops in this passage. Like the leaves that had unfolded and expanded in the warmth of spring but now are withering with the onset of autumn, so Victor's health steadily declines and withers the more he pours his energy into his work. Victor's choice, then, to isolate himself from his colleagues, friends, and family has disastrous effects on his mental, emotional, and physical well-being. "I had worked hard for nearly two years, "he

reflects, “for the sole purpose of infusing life into an inanimate body. For this I had deprived myself of rest and health” [5].

Indeed, shortly after he brings the creature to life, Victor collapses and succumbs to what he calls a “nervous fever” for the better part of a year [5]. He uses terms like “sickness,” “ill[ness],” and “disorder” to describe his condition at that time [5]. In fact, so grave is his illness that he refers to himself as “lifeless” and in need of being “restored to life” [5]. Ironically, just as Victor had animated the lifeless corpse of the creature, now he stands at the brink of death in need of life-giving revival. Fortunately, Victor is visited by a dear childhood friend, Henry Clerval, who cares for him and helps him regain his strength. Were it not for his friend’s intervention, though, Victor may not have recovered.

So, why take the risk? Why does Victor isolate himself and risk his health and well-being? As noted, Victor’s scientific pursuits have become something of a personal obsession [23]. He is driven to succeed, and that leads him to cut himself off from the people in his life so he can devote himself entirely to his work. But are there other motivations for his isolation besides professional success?

Something he says in the passage above may be telling: “the fall of a leaf startled me, and I shunned my fellow creatures as if I had been guilty of a crime” [5]. Does Victor work in seclusion and secrecy because, at some level, he suspects that what he’s doing isn’t right? Is some part of him aware that he’s committing a kind of violation or transgression: against nature, against his own conscious, against an unwitting world, ignorant of and unprepared to shoulder the consequences of his choices [23]. Later, in retrospect, Victor condemns his techno-scientific efforts as “unhallowed arts” [5]. He regards himself as guilty for the murders the creature commits because he knows at some level that he shares responsible for the creature’s actions. “This also was my doing,” he acknowledges, “all was the work of my . . . accursed hands” [5].

But back in the workshop, he has only a faint sense of guilt. But that nascent sense of moral unease may have been enough to send him into hiding. For someone like Victor, there can be an advantage to isolating and working in secret. If no one knows what he’s doing, then no one can hold him accountable or intervene to stop him. So, Victor’s isolation may caution against science and engineering work that is performed in secret, that is non-transparent, and that leaves the public uninformed of the risks and so unable to speak into the process or give consent [27], [28].

There may be something else that drives Victor into seclusion and compels him to throw himself tirelessly into his work. Shortly before leaving for university, Victor experiences a profound personal tragedy. His beloved mother dies of scarlet fever while caring for a sick child. The experience of her death shakes Victor, but there are indications that he may not have the emotional resources to come to terms with the loss and process his grief. Although Victor speaks of the “despair that is exhibited on the countenance” in the wake of a loved one’s death and the “bitterness of grief,” he concludes somewhat abruptly that “[t]he time at length arrives when grief is rather an indulgence than a necessity” [5]. And he speaks with admiration of his adopted sister and fiancée Elizabeth, who “veiled her grief” and “forgot even her own regret in her endeavours to make us forget” [5]. After a relatively short time of mourning, then, Victor resigns

himself to proceed with his plans to attend university: “My mother was dead, but we had still duties which we ought to perform; we must continue our course with the rest” [5].

Once in Ingolstadt at university, is it accidental, then, that Victor’s great scientific mind turns to the problem of human mortality and the challenge of reanimating the dead? Could it be that Victor isolates himself from his family in part out of grief, unwilling or perhaps unable to process his recent experience of death and loss. Earlier, while still grieving at home, Victor admits that he “was new to sorrow” and “alarm[ed]” by the experience of it [5]. Perhaps, then, at some level his repressed pain motivates him to use his scientific and technical knowledge to “break through” the “bounds” of “life and death,” as he says, in order “to renew life where death had apparently devoted the body to corruption” [5].

The idea that Victor has been repressing and redirecting the painful loss of his mother gains force from a dream he has just after he brings the creature to life. That very night as he sleeps, he sees the face of his fiancée, Elizabeth. And he moves toward her to embrace her. But as he places a kiss upon Elizabeth’s lips, they turn a deathly pallor. Then, Victor watches in horror as Elizabeth’s features change to resemble those of the rotting corpse of his dead mother [5]. It’s as though all of Victor’s deepest fears and unresolved anguish in the wake of his mother’s death surface at last. But the nightmare may also conceal a foreboding warning. In his isolation and seclusion, in his neglect of those he cares for most in this world, Victor has left them vulnerable. In giving life to the creature, then, Victor may have unwittingly bestowed on his family the kiss of death [29].

Victor’s story thus cautions against isolation, whether professional or personal. For many undergraduates, college can be a convenient place to disappear, especially in times of adversity and pain. Too often, many students feel lonely and alone at the very times when friendship, support, and guidance are most needed [30]. If we’re inclined to socially isolate ourselves, to go into hiding and withdraw, especially when we’re under pressure or in pain, then Victor’s example cautions us. Although Victor failed to ask for help, without the intervention of his childhood friend to care for him, he probably wouldn’t have made it. Victor’s self-isolation also encourages engineers to bring their work into the light, to practice transparency and openness in research and design, and to give others the privilege of sharing in their work, especially those stakeholders who are likely to be most affected by it. Solitude, isolation, seclusion, secrecy: those are choices. But there are other choices available: openness, collaboration, transparency, accountability, even vulnerability. Had Victor made such choices, perhaps he wouldn’t have had to endure such physical and mental anguish, at least not alone, and the results and consequences of his work might have turned out differently for all involved.

Bias

Another of Victor’s professional failings the novel cautions against is bias or prejudice in techno-scientific practice. In doing so, the novel warns against a possible self marred by unexamined and unreformed biases that can take expression in the process of technological design. For Victor, there seems to be something of an ax to grind behind his project to make the creature and bring him to life. Think for a minute about what that undertaking involves and what it implies. When Victor sets out to make the creature, he works alone to create life. In other words, he

engages in a kind of solitary act of reproduction that bypasses natural or conventional modes of human procreation [29].

That's why the novel uses language and imagery of sexual reproduction to characterize Victor's scientific and engineering work [23, 29]. Note how Victor reflects on his initial discovery of the causes and source of life: "The astonishment which I had at first experienced on this discovery soon gave place to delight and rapture. After so much time spent in painful labour, to arrive at once at the summit of my desires, was the most gratifying consummation of my toils" [5]. Delight, desire, rapture, gratification, consummation, painful labor – these are words often used to describe sex, reproduction, and childbirth. But here, they're used of Victor's efforts to bring life to the creature. Victor's techno-scientific work thus takes the form of an act of technological procreation and engineered human reproduction.

But there is something, or rather someone, conspicuously absent from this enterprise. There is no woman! She's not involved. She's frankly not needed. Victor has done this all alone [23], [29], [31]. Through science and technology, Victor has effectively eliminated the woman from the process of human reproduction and in so doing, as one scholar notes, robbed women of a significant source of culture power [31]. In fact, Victor's project has the potential to eliminate the need for women and mothers entirely; it involves a man creating another man without a woman [31].

Victor's work, then, effectively marginalizes and excludes women from the process of scientific inquiry and technological design. Men get to do everything. Women need not apply. So, part of the novel's cautionary tale concerns biased practices of science and engineering that exclude women in the interest of reinforcing traditional structures of male power, privilege, and prestige. As one scholar notes regarding technological design, "denying women access . . . is a way of protecting a distinctly male arena" [32].

This theme of biased techno-science shows up again later in the novel when Victor considers making the creature a female companion. Several years after his animation, the creature tracks down Victor and requests from him a female partner so he won't be alone and miserable in the world, the only one of his kind. And Victor, moved for the first time with a measure of compassion and a sense of responsibility, initially agrees. But just as Victor has all the bodily parts of the female creature arranged on the table, just as he's about the animate her and bring her to life, he stops. In a somewhat uncharacteristic move, he reflects on the potential consequences of his actions. And he starts playing out various "what if" scenarios. This time, Victor admits that he has no idea what he's getting himself into. He doesn't know who this female creature will turn out to be, and he has no real control over who she will become. "I was now about to form another being," he considers, "of whose dispositions I was alike ignorant" [5].

Then, Victor starts entertaining wild possibilities. What if she ends up being ten thousand times more evil and "malignant" than the original male creature? What if she delights in murder and carnage for its own sake? Further, and more to the point, she's going to be a "thinking and reasoning" being with a mind and will of her own [5]. What if she doesn't want to go along with the plan Victor and the creature have concocted? What if, after Victor brings her to life, she refuses to be the partner and companion of the male creature? That was the arrangement Victor

had brokered with the creature. But what if she doesn't want any of that. What if she has ideas and intentions of her own that can't be managed and controlled by the two men [31]?

And so, utterly terrified at this prospect, Victor tears her lifeless body apart, limb from limb, and disposes of the remains in a nearby river. He can't bring himself to go through with her creation, so he destroys her while he still can in what is, perhaps, the most violent act in the novel. As one scholar points out, in the act of destroying the female creature, Victor "reasserts male control over the female body" [31]. Her destruction effectively reverses the threat her creation represents to traditional arenas of male power.

Further, Victor's actions give expression to ideological notions of science that are rhetorically hostile to women. These rhetorical constructions of techno-science were prevalent when Shelley wrote the novel. For example, in a famous published lecture English chemist and inventor Humphrey Davy (1778-1829) declares that science "has bestowed on him [the male scientist] powers which may be almost called creative; which have enabled him to modify and change the beings surrounding him, and by his experiments to interrogate nature with power, not simply as a scholar, passive and seeking to understand her operations, but rather as a master, active with his own instruments" [33]. The reference to the scientist as "master" in Davy's rhetoric, coupled with the use of masculine pronouns to refer to the scientist and feminine pronouns to refer to nature, yield the image of an empowered male scientist poised to exploit a more vulnerable female-gendered nature [33].

This sort of gendered rhetorical imagery echoes language earlier used by English philosopher and statesman Francis Bacon (1561-1626), who is known for elaborating what would become the scientific method. Bacon famously argues that modern science will bring about "the truly masculine birth of time," which will facilitate "the domination of man over the universe" [23]. Bacon proceeds to celebrate the capacity of modern science to subdue and exploit a female-gendered nature: "I am come in very truth leading to you Nature with all her children to bind her to your service and make her your slave" [33, 34].

As scholars have noted, this discourse of the scientist as empowered master exercising violent control over a passive, female-gendered nature influenced Mary Shelley's portrayal of Victor Frankenstein [23], [31], [33]. Shelley's narrative effectively poses the question: what would it look like were the vision of Bacon and Davy to be realized in Victor's techno-scientific work? What kind of consequences, what kind of world, would that yield? The results of Victor's project suggest that such an enterprise would be nothing less than monstrous [33].

Victor's story thus cautions against the kind of biased science and engineering that would minimize the contributions of women or exclude them outright from an otherwise all-boys club [35]. In so doing, it warns against biases in engineering practice directed not only toward women but also toward other minoritized and marginalized groups, especially as it concerns technological processes or products that should involve and include everyone. Whether motivated by repressed grief and anger over his mother's death or hubristic delusions of self-importance, Victor's project results in the exclusion of women from the process of scientific and technological development. As such, it robs women of the opportunity to contribute meaningfully to fields of inquiry in which all humans have a stake.

Conclusion

Irresponsibility, presumption, isolation, bias – these are some of the concerns about the unethical practice of techno-science the novel registers in the figure of Victor Frankenstein. But Victor was right about one thing. Scientists and engineers have "astonishing . . . power placed within [their] hands" [5]. What resources can undergraduate engineering programs provide to cultivate students' moral imagination and encourage them to use the power of engineering design to work for social good? As a cautionary tale of science fiction, *Frankenstein* offers rich conceptual resources for engineering students to imagine possible selves, in contrast to the "salient other" of Victor Frankenstein, that embody values of socially responsible engineering practice. These values include care and responsibility, circumspection and forethought, openness and accountability, and equity and inclusion. The analysis above has considered the capacity of Mary Shelley's novel to contribute to ethical identity formation for engineering undergraduates. Further research could explore excerpts of student work to determine how students enrolled in the courses described above engaged with Victor's (un)ethical example to articulate possible selves more aligned with values of socially responsible engineering practice.

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