ARTICLE

Engineered Violence: Confronting the Problems of Neutrality and Violence in Engineering¹

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Engineering educators continue to challenge the social/technical dichotomy by framing engineering as a set of non-neutral activities. Faced with the historical realities that engineers are often “hired-guns” for military interventions and capital accumulation, educators have sought to establish new canons for engineering ethics that are based on paradigms of peace and critically engaged pedagogies. We aim to situate nuanced understandings of violence—as understood by 21st century environmental and racial justice movements in the United States—into the larger goal of reorienting engineering ethics for a more peaceful and socially just world. Literature is presented about challenging what we identify as the “neutrality problem” in engineering education. We argue that theories of interpersonal and structural violence will better help engineers confront the neutrality problem in classrooms and workplaces. Our ultimate goal is to open up a larger research agenda on violence for engineering educators and practitioners.

To the often-heard question, Who are they, this new generation? One is tempted to answer, Those who hear the ticking. And to the other question, Who are they who utterly deny them? The answer may well be, Those who do not know, or refuse to face, things as they really are.

Hannah Arendt, *On Violence* (1970, p.18)

INTRODUCTION

On Election Day 2016, two Catholic Worker activists, Jessica Reznicek and Ruby Montoya, used oxygen and acetylene to melt through empty pipeline valves, sabotaging the controversial \$3.8 billion Dakota Access pipeline and stopping construction for weeks (Democracy Now 2017). The following July the two activists publicly took responsibility for the sabotage in the hopes of inspiring others to follow suit in the tradition of the anti-nuclear Plowshares movement of the 1980s, where faith-based leaders also engaged in direct action and sabotage. In a public statement Montoya says,

Some many view these actions as violent, but be not mistaken. We acted from our hearts and never threatened human life nor personal property. What we did do was fight a private corporation that has run rampantly across our country seizing and polluting our nation’s water supply. (Democracy Now 2017, para. 4)

¹This article is adapted from a paper submitted to the American Society for Engineering Education’s 2017 Annual Conference under the title “Teaching the Non-Neutral Engineer: Pathways toward Addressing the Violence of Engineering in the Classroom.”

In this statement, Montoya flips common engineering wisdom on its head: the Army Corps of Engineers' efforts to keep the Dakota Access Pipeline in working order are the ones committing an act of violence and saboteurs (in this case, Montoya and Reznicek) are counteracting, lessening, or diverting that violence. In essence, competent engineering can be violence if it is in the service of a project that can reasonably be regarded as dangerous or capable of inflicting a more direct kind of violence upon completion. It is certainly worth following this logic and seeing where we end up. What basic assumptions in engineering feed into violence as Montoya, Reznicek, and —as we will explore— many others define it?

Given engineers' roles in maintaining and dismantling the socio-technical world, we argue that engineering educators can leverage the understanding of human safety, property, and violence by those in environmental and racial justice movements to help engineering students better understand their role as political actors. Indeed, engineering educators have pointed to a persistent pedagogical problem that positions the engineering disciplines in apolitical and neutral terms. We call this the "neutrality problem" and describe it as placing moral weight not on the work of engineers but instead the ad hoc uses of engineered artifacts. The problem appears in common assumptions that, for instance, bulldozers or cars are only as violent as their users intend them to be, absolving engineers of moral responsibility for the socio-technical outcomes that they help to produce. The "neutrality problem" has a long history of being challenged by critically engaged engineering educators. Some challenge the problem by calling for "non-canonical engineering ethics canons" (Riley et al., 2015), others advocate for a "peace paradigm" to be included in ABET criteria (Catalano, 2004; Catalano and Baillie, 2006), and in the classroom they incorporate critical pedagogies to bear on macro-ethics, such as war and globalization (Nieusma and Blue, 2012; Muscat et al., 2015). Building on this work, we argue for more nuanced understandings of how violence, as conceived of by those who are part of 21st century social movements, from Indigenous Water Protectors to Catholic Workers, can help educators construct pathways for non-neutral engineering education.

We begin with a literature review of the neutrality problem in engineering education. Next, we insert a question into the discussion: What do engineers need to know about the enactment of and resistance to violence to advance social justice goals in engineering work? Here we define intersections of interpersonal violence (violence between people) and structural violence (the violence of social structures and institutions) in relation to property destruction and property maintenance. After these terms are defined, we show how property destruction and violence differ in important ways using two case studies. In the first case, we use environmental activism to show how intentions to shut down oil pipelines are actually consistent with ideologies of nonviolence. In the second case, we show how outdoor seating areas have been designed to make it hard for homeless people to rest and how those engineers who are making this new kind of street furniture are in fact enacting a form of violence against this population. Finally, we propose an engineering education research agenda on violence. This agenda should aim to explain how intersecting forms of violence in the context of property destruction and maintenance helps challenge the neutrality problem as presented by non-canonical engineering ethicists, "peace paradigm" advocates, and critical pedagogues.

VIOLENCE AND NEUTRALITY IN ENGINEERING EDUCATION

In 2016, social scientists Diego Gambetta and Steffen Hertog published the controversial book, *Engineers of Jihad: The Curious Connection Between Violent Extremism and Education*. As the title suggests, the book probes why there is an overrepresentation of people with engineering degrees in right-wing fundamentalist groups, most notably Jihadi terrorists but also Nazis, white supremacists, and other

extremists. While the book offers compelling evidence to support a correlation between violent fundamentalism and engineering education, it is primarily concerned with drawing connections between the two based on the personality traits of individuals. This leaves the practices and curriculum of engineering education black-boxed: personalities prone to fundamentalism may be attracted to engineering, enter engineering education programs, and leave still prone to fundamentalist ideologies. By ignoring what engineering actually looks like in the classroom, Gambetta and Hertog (2016) provide little insight into how real-time education may leave violent ideologies unchallenged or actually reinforce violent and fundamentalist mindsets. Missing from their understanding is literature on the neutrality problem in engineering education, which has long revealed how curriculum and structure are entangled with violence. This literature is also normative, offering avenues to challenge the violence perpetuated by those with the stance that engineering work is and can achieve apolitical neutrality, a political position in and of itself (Riley, 2008).

Nieusma and Blue (2012, p.53) explain the historically violent origins of the term “engineer,” as “one who operates siege engines--early technologies of warfare.” Tracing this to the present, they argue that “militarism and cultures of warfare” have shaped the relationships between industry (directly connected to war and not) and engineering education (Nieusma and Blue, 2012, p.56). At one level engineering labor is designed to fit into existing power structures and organizational logics. David Noble (1977) explores the history of this fit in the U.S., tracing the curriculum and structure of engineering education to military interests of the 1920s. While much has changed since then, the legacy of “command-and-control problem solving”--a system of military planning that restricts inquiry to strict causation--persists in engineering education today as the demarcations between the social and the technical (Nieusma and Blue, 2012).

At another level, engineering epistemologies assume an apolitical and neutral stance that much of engineering’s history does not meaningfully impact present day practices. Leyden et al. (2012, p.70) suggests that many engineers assume that bias-free knowledge is possible by focusing on practices that promote “social cohesion,” and “efficient, and interdependent functionality,” but this illusion of neutrality is only possible because these are practices that are already commonplace in engineering. Indeed, Donna Riley (2008) points out that creating a dichotomy between engineering and politics is based in a political stance that assumes it is possible to separate them in the first place. Alternatively, literature in science and technology studies reveals that knowledge production is always situated in socio-political contexts (Haraway, 1988; Harding, 2008).

If we add the legacies of violence that persist in engineering education and industry, to the present-day illusion of neutrality described above, it becomes clear that the disciplines of engineering provide little opportunity for practitioners to be reflective about their roles in perpetuating violence. Fortunately, reflective research on the intersections of engineering/liberal education and engineering/sustainability appears to be growing (Tang 2014; Wilcox and Akera 2014). This research helps to support a vocal minority seeking alternative forms of engineering education that are not rooted in violence. Upon recognizing the long-standing role of engineers as hired guns for the military-industrial complex, these educators and researchers have used frameworks of peace (Catalano, 2004) and critical pedagogy (Riley, 2003) to propose reforms that help to realize the democratic possibilities of the engineering disciplines.

The language of peace in these reform proposals prioritizes engineers’ social responsibilities to the safety, health, and welfare of humans and the Earth over that of war and corporate profit (Catalano and Baillie, 2006; Catalano et al., 2008; Nieusma, 2011). This approach includes everything from practical advice on career paths and how to decline working on ethically dubious projects, to more structural critiques of engineering firms’ relationships to state violence. One of the most influential efforts to scale the language of peace into engineering education and profession is George Catalano’s 2004 proposition to modify the

Accreditation Board of Engineering and Technology (ABET) Criterion 3, which deals primarily with student learning outcomes such as “ability to design and conduct experiments” and “ability to communicate effectively.” Catalano suggests reorganizing this section so that the ethics of living in peace with others, the planet, and ourselves is brought to the forefront.

Riley and Yanna Lambrinidou (2015) extend Catalano’s peace paradigm into an ethical principle where engineers reflect on their profession’s history with militarism and environmental destruction to ultimately resist historical repetition through studying the socio-technical complexities at local and global scales. For example, Muscat et al. (2015) documents how engineers are often positioned within “violent conflict situations arising from geopolitical disputes, rival claims over resources, unequal distribution of benefits and costs or power struggles.” Consider the U.S. Army Corps of Engineers’ role in the decision to save \$100 million at the cost of canal wall failures that resulted in the massive flooding of New Orleans from hurricane Katrina (Rogers et al., 2015); or the Corps’ role in house demolition post-Katrina, despite community protest.

Critical pedagogies have also been at the center of alternative engineering education (Riley, 2008; Lachney, 2014; Nieusma and Malazita, 2016). Given the historical racial dynamics that excluded African Americans from entering the engineering disciplines (Slaton, 2010) and the long-lasting struggles that persist for women trying to enter the field (Bix, 2015), Riley (2003) proposes the use of feminist and critical pedagogies to address the need for all students to recognize the political, non-neutral nature of engineering while being responsive to the needs of women and minority students. Drawing on the liberatory pedagogies of bell hooks (1994) and Paulo Freire (1970), she argues that engineering education should be student-centered and problem-based—traditions familiar to engineering educators—with an increased focus on diversity and accessibility that is based in racial justice and gender equity.

This paper will contribute to educational reforms efforts that are based in the frameworks of peace and critical pedagogies that seek to challenge the neutrality problem. We believe that engineers and engineering educators will be able to deepen their engagement of the neutrality problem with students by drawing on more nuanced understandings of violence that is based in the work of environmental and racial justice movements. We will present a typology of violence, followed by two case studies that challenge mainstream understandings of violence and nonviolence in U.S. politics.

ENGINEERING VIOLENCE

Violence is, unfortunately, something all people understand at some fundamental level. At the interpersonal level, that is between identifiable actors in a discreet scenario, common-sense definitions of violence are accurate. It is obvious to most people that when one person inflicts physical pain on another outside of mutual consent by both parties, violence has occurred. Even harsh or intense verbal interactions could be considered violence, especially if such language has been known to cause psychological trauma. Violence immediately becomes more complicated when structures or even technologies are implicated in sustained violent acts. Indeed, the World Health Organization (WHO) defines violence as “The intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, that either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation.” (Krug, Dahlberg, Mercy, Zwi, & Lozano, 2002, p.5)

The last two results of use of force or power, maldevelopment or deprivation, suggest that violence can occur over a long period, perhaps even being generational in nature or the result of complex projects that

hinder what would otherwise be an expected development. The diversion or pollution of a river that is the sole source of drinkable water for a community, for example, constitutes both deprivation and infliction of maldevelopment. In the U.S., *We the People of Detroit* (2016) characterized the ongoing water shutoffs in Detroit and the poisoning of Flint's water supply as the intentional results of an austerity regime that sought to dismantle the wealth and assets of Michigan's African American communities. Following *We the People of Detroit's* fights against household water shutoffs, the United Nations accused the city of human rights violations (*We the People of Detroit* 2016).

The neutrality problem intersects with concepts of violence when the construction and subsequent maintenance of engineering projects pose a threat—either direct and immediate or gradual and compounding—to individuals or groups. Violence need not always be as intentional or direct as it is in interpersonal interactions and can, in fact, be obscured by one's mundane work schedule. We contend that when engineers refuse to take an explicit position in such cases, or export concerns of violence to policy makers, elected officials, or managers, they are just as likely to perpetuate violence as to prevent it. Alternatively, if engineers were taught to be aware of their potential role in perpetuating violence and given opportunities to ethically reflect on the cases of engineering violence they would be in a much better position to find alternative, non-violent solutions to design problems.

TAXONOMY OF VIOLENCE

Not all situations are as clearly violent as depriving people of their sole source of water. Therefore, what follows is a taxonomy of violence that engineers may use to navigate the ethical situations that they find themselves in. This taxonomy is not meant to be exhaustive nor will it act as a decision matrix for every situation. It is merely an introduction to a complicated topic that has been neglected by the disciplines for far too long.

Interpersonal

Our working definition of interpersonal violence is a modification of the WHO's definition of violence in general: The intentional use of physical force or power against another person that either results in or has a high likelihood of causing physical or psychological harm. As stated above, interpersonal violence is straightforward and recognizable. Punching someone in the face is violent. Violence can also take the form of psychological abuse that may or may not manifest in physical harm on bodies. It is important to note here that even the most straightforward and clear instances of interpersonal violence (like getting punched in the face) can be seated in and reinforce overarching structures of continued violence and technological development.

Technological development, regardless of the intention of the designers, can amplify or increase the likelihood of interpersonal violence. Consider, for example, the adoption of TASER stun guns by police departments. The development of non-lethal weapons was meant to give officers the ability to subdue suspects without resorting to lethal means. However, a comprehensive study of police departments' adoption of stun guns showed a six-fold increase in in-custody deaths in the first year of use (Lee et al., 2009). This case demonstrates that not only are direct interpersonal acts of violence embedded in larger structures of power (i.e. the relationship between police officers and minority civilians) but the intentions of engineers is not synonymous with engineering outcomes: the presence of stun guns has increased in-custody deaths, not decreased them.

Structural

Catalano and Baillie (2006) go as far back as Dante Alighieri to build out their concept of peace that includes not only the absence of war or violence but the active implementation of justice. This is essentially what is needed to overcome structural violence. The concept of structural violence is largely attributed to the mathematician and sociologist Johan Galtung in his 1969 article in *Journal of Peace Research*, "Violence, Peace, and Peace Research." There he argued that violence is structural in nature when it lacks the obvious subjects and objects of interpersonal violence. Galtung gives the following example, "in a society where life expectancy is twice as high in the upper as in the lower classes, violence is exercised even if there are no concrete actors one can point to directly attacking others, as when one person kills another" (1969, p.171).

There is unfortunately a wide range of well-known examples of structural violence related directly to the engineering profession. We will reserve extended ones for the preceding case study section but it suffices to say here that the selection of projects, the choosing of which parts of any given project get "value engineered" out of the original plans, the siting of projects, and the intended users of a technology can all contribute to structural violence.

PROPERTY DESTRUCTION, DEFACEMENT, AND SABOTAGE

One may already notice the large moral quandaries that this topology brings to the fore. If technologies are active participants in violence, when is it morally appropriate to destroy that technology or artifact? What is the difference, for example, between breaking the window of a Starbucks and setting fire to a black church in the U.S.? The answer here lies in how the act of property destruction fits into a larger history of structural violence. There is a sad and shameful history in the U.S. of white supremacists burning down churches attended by African Americans as a means of psychological intimidation and destruction of places used for community organization. In judging whether an act of property destruction, defacement or sabotage is violent one must do nothing less than assess the meaning of the object in question and the nature of the defacement or destruction. Or, put more eloquently by the author and journalist Emma Goldman, "Beyond every violent act there is a vital cause" (2013, p.26). Understanding the "vital cause" of not only the person doing the property destruction but of the technology that has been destroyed is crucial.

To get a sense of how historical context and relevant actors matters in the moral calculus of whether the destruction of property is violent or defensive, consider the connections Raven Rakia makes between the slave trade and the 2013 uprisings in Ferguson,

Since colonization and the Trans-Atlantic Slave Trade, white wealth has been and continues to be built off the backs of black labor, off the exploitation of African resources and bodies. But wait for the courts to grant reparations, and remain waiting. Looting is the opposite of apolitical; it is a direct redistribution of wealth. And yet, even on the left, when a black or African protester destroys and takes property, they are stripped of the tactical or historical will inherent in the decision. It is instead understood through the colonial conception of the political backwardness of black communities: they become apolitical rioters, pure and simple. (Rakia, 2013)

Another (understandably!) counterintuitive notion related to the taxonomy above is that the maintenance of the sociotechnical systems that are integral to structural violence is more violent than acts of property destruction issued by individuals or even individuals organized within social movements. Here we would refer engineers back to Galtung's definition of structural violence to help understand why, as Muscat et al. report,

engineering decisions have sometimes resorted to violence to resolve disputes not settled through negotiation or orderly political process. In some cases, engineering projects have deepened inter-group animosities that may have arisen initially for other reasons – religious, cultural, economic or political. (2015, p.26)

As we show in the next section the development and subsequent maintenance of technologies are part and parcel of structural violence and may also increase the likelihood or prevalence of interpersonal violence. By virtue of these facts alone, it is incumbent upon the engineering profession to produce engineers that are fluent in the social consequences of technology.

PROPERTY MAINTENANCE AND PROPERTY DESTRUCTION

This section will demonstrate the utility of structural violence as a means of understanding the differences between property destruction and violence. We do this by drawing as stark a distinction as possible by showing that property *maintenance* can be more violent than property *destruction*. It is important to state unequivocally that not every instance of property destruction is nonviolent (as church burnings attest) and all instances of property maintenance are not violent (rebuilding Flint, Michigan's water infrastructure would not be a violent act).

In considering the above topology, it is important to not conflate war with violence. War, to quote Nieusma and Blue is a “means of naming differences in power, in wealth, and in wellbeing, which persist between and within national frames. Warfare, in this sense, is a strident conceptualization of social conflict as well as the measures taken to ensure or combat its persistence” (2012, p. 54) Violence is a large component of war, but not all violence is associated with warfare. Therefore, a dogmatic adherence to nonviolence in the name of peace overlooks a long history of effective armed resistance and defense against warfare. The language of peace should not be mobilized in the way U.S. liberals and the right have used it: to discredit social movements that employ a “diversity of tactics”—which may include property destruction or defensive violence—to achieve their goals.

Peter Gelderloos (2014) among others (see also Meckfessel, 2016) have explored how dogmatic adherence to nonviolence can hamstring social movements, especially those resisting unjust wars. From the Zapatistas’ armed struggle against neoliberalism to black communities’ armed defense against the KKK and police malfeasance, violence has been used defensively to thwart larger threats of organized violence.

PROPERTY DESTRUCTION AND TAMPERING AS NON-VIOLENCE

Property destruction is not always violent, although it can be a component of warfare or a tactic in inflicting violence on individuals or groups. This is an important distinction, especially when one takes into consideration how, historically, certain lives have been considered property. (See, again, the block quote in the previous section from Raven Rakia.) Property destruction is a form of nonviolence, generally, if it intercedes in warfare and larger interpersonally or structurally violent acts, as the two Catholic Workers previously discussed make clear.

As of this writing there is a robust resistance to the construction of the Dakota Access Pipeline (DAPL) by the Standing Rock Sioux Tribe and their allies. DAPL (and oil pipelines in general, as recent history has shown) presents a high likelihood of causing harm, maldevelopment, and deprivation of vital resources. Water Protectors’—the self-chosen name for the Standing Rock Sioux who aims to prevent the

construction of the DAPL—and their allies efforts to halt construction of the pipeline by sabotaging construction equipment and literally standing in the way of construction have clear connections to a long history of indigenous peoples halting dangerous infrastructure projects going at least as far back as the mid 19th century and the construction of the intercontinental railroad network. Construction of railroads had to be done under armed guard at significant expense to the railroad companies due to confrontations with indigenous peoples defending the land they had occupied for centuries (Bailey, 2007; Gordon, 1996; Moody, 2002).

Resistance to the pipeline is, on the one hand the quintessential example of property destruction as non-violence, but on the other it is an outlier for how much attention it has received. The pipeline, which was originally set to be built north of Bismarck but was redirected due to concerns over municipal water contamination, now threatens cultural sites and water sources for the Standing Rock Sioux Tribe who are downriver of Bismarck (Mone & Nicholson, 2016; Thorbecke, 2016). Bismarck, whose population is 92.4% white (U.S. Census Bureau, 2010), did not even have to engage democratic means to halt the pipeline because the importance of securing the safety and well-being of the city of Bismarck was taken for granted. The safety of the Standing Rock reservation was not. Given the clear implicit decision to value white lives over Native Americans in the routing plans, Water Protectors and their allies must directly interfere with pipeline construction because they are afforded no other means of having their voices heard in the decision-making process. Preventing the pipeline is a clear means of interceding in a centuries-old war waged on indigenous peoples of the North American continent.

PROPERTY MAINTENANCE AS VIOLENCE

Given the differences between war, violence, and property destruction described above, engineers would do well to reconsider how some of their work may contribute to warfare or violence in the name of preventing property destruction. The construction of DAPL is a clear example of the construction of new engineered systems that inflict violence but in this section, we would like to demonstrate how the maintenance of property—specifically how property is maintained to benefit a specific subset of people over another—can also be a form of violence or even warfare. To demonstrate property maintenance as violence we turn to the myriad ways outdoor seating areas have been designed to make it impossible for homeless people to rest or even congregate.

Victor Papanek recognized the implicit political ramifications of designed objects when he wrote that a designer's professional responsibilities, "go far beyond" the success of any one project. The designer, instead, must ask whether their project is, "on the side of the social good or not" (1985, p. 55). A clear example of designers and engineers ignoring such a basic question can be found in the civic design of the street furniture that adorns the public spaces of most cities. The safety and quality of life of housed and homeless peoples are often in direct contradiction. City officials are in the unenviable position of having to provide services that help both categories of residents. Overall, cities tend to placate housed residents and act violently to the homeless when these groups' interests diverge. In addition to forced relocation and police violence, the very built environment around them is constructed to prevent sleep or even shelter from inclement weather. From bus benches with arm rests that prevent lying down to overpasses with spikes posted on the covered ground beneath, engineers and designers have removed the last semblance of sheltered space for the homeless as part of a larger war, as defined by Nieusma and Blue (2012), against the poor.

Without these designed and engineered objects, a human would have to face another human and demand that they move. They may also be forced to notice that a homeless problem exists, rather than hiding it

by pushing homeless people further out of the public eye. Hiding a problem, rather than engaging its root cause, should be a red flag for any engineer.

DISCUSSION: IMPLICATIONS FOR EMERGING SYSTEMS

In this section we would like to move into a more speculative mode. Whereas our case studies have looked at very specific instances of property destruction and maintenance, our discussion will put these concerns in context of a broader research agenda that would integrate definitions of violence into engineering education and research. Peace paradigm advocates and critical pedagogues have sought to confront issues of violence in the classroom, before they take root in actual engineering projects. While these social justice oriented educators are our target audience, it is our hope that this initial discussion will open up a research agenda on violence for engineers and engineering education researchers more generally. It is our position that the language of violence and nonviolence must become our engineering design and practice if a peace paradigm, or equivalent alternative, is going to be realized.

Just as any professional engineer wouldn't incorporate a known faulty part into a machine, engineers should know and understand that automating a systematic injustice is itself a kind of negligence. Directly participating in designing, implementing, and maintaining systems that can reasonably be thought to cause violence is not a politically or even professionally neutral decision. We are not asking engineers to be fortunetellers, predicting whether or not anything they make could ever be conceivably used in a violent manner. Rather we are demanding that engineers be partisans in the political controversies that they are deeply involved in and aim to reconstruct socio-technical relationships in more equitable ways (Woodhouse 2005). At the very least, newly minted engineers must be taught that anything they make could be used by anyone for any purpose. It is no longer acceptable for engineers to be taught (implicitly or otherwise) that their creations are as good as their users' intentions. There are too many historical lessons—from Nobel to Kalashnikov to Heisenberg—wherein engineers regret their participation in subsequent widespread violence.

Specific pedagogical interventions may involve entire courses devoted to students exploring how societies would behave if every single person had access to something they had made, or researching real world examples of differing levels of access to deadly technologies. This may require that engineering departments advocate within their institutions for interdisciplinary collaborations with other departments to enrich existing curricula for both. How the bomb changed global geopolitics might be discussed between political science and nuclear engineering departments. What the automobile and its commitment to highways did to urban neighborhoods would be a good topic for urban studies and automotive engineering students to explore. How police body cameras are changing the relationship between police and the communities they work in is going to be a crucial problem for mechatronic engineers and sociologists. Each of these examples, and many others, must be seen as fundamental to engineering pedagogy as tensile strengths of materials and torque strengths of gears.

Given that the above recommendations are not without precedent, how would these recommendations fit within engineering education? Design and engineering programs are already making interdisciplinary connections, integrating sociology, anthropology, and political science research into their curricula. The Programs in Design and Innovation (PDI) at Rensselaer Polytechnic Institute is a prime example worth learning from (Nieusma, 2015). PDI's studio series is the first and still one of only a handful of undergraduate programs housed within a social science department and coupled with standard engineering curricula. PDI students' training is equal parts ethnographer and engineer, the result of which is inquisitive, technically adept professionals who understand that their creations are also arguments:

physical instantiations that project a specific kind of politics (Winner 1986). Students in this program frequently go on to choose professions in socially conscious organizations. PDI should be understood as the first draft of a revitalized engineering pedagogy that is aware of its social and political role in the world.

CONCLUSION

In this paper, we have argued that engineering pedagogy would benefit greatly from deep engagement with social movements' understandings of violence and nonviolence, both how they work and what role they can play in fundamental engineering design. By making engineers fluent in both interpersonal and structural violence, institutions of higher learning would make a significant impact in a wide range of topics that dominate the news. From ecological disasters to humanitarian crises, engineers, whether they acknowledge it or not, are complicit in the tragic failures of governments and private organizations, not just their successes.

In this conclusion we would like to pull one last example from the headlines. Facebook, in the wake of the 2016 American presidential election, refuses to acknowledge its role in spreading misleading or outright false news stories to the public (Frenkel, 2016). This is in stark contrast to 2011 when it proudly proclaimed (along with Twitter and other social media companies) that it had been integral to grassroots regime change in the Middle East. It should no longer be acceptable that engineers take credit for successes but brush off negative consequences to political actors. Engineering—because it automates, eases, or otherwise augments social action—is a political discipline and must act as such. Engineers, whether they build bridges or databases, must have the analytical skills to navigate the complex political controversies they are implicated in. Anything less is an abdication of responsibility by their forbears.

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