Engineering the Body, Mind, and Soul:

Engineering's endurance in a technoscientific society and the creation of new entities through power/knowledge assemblages and practical scientific technologies in education

by

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Abstract

This dissertation explores the significant role of knowledge and engineering in shaping society, with a focus on the Enlightenment period's emphasis on science and its practical applications through engineering and technology. While recognizing the contribution of practical expertise and technoscientific awareness to societal progress, the dissertation argues that over-reliance on particular science and societal assemblages can result in narrow and biased perspectives in societies that depend on limited forms of knowledge and power. To address this issue, the dissertation emphasizes the need for educators to adopt a critical approach to education, examining the limited view of science and promoting a more inclusive understanding of initiatives like STEM education. Additionally, the dissertation examines the present-day impact of engineering practices on shaping society, with a particular focus on how engineers are trained and formed. Finally, the dissertation underscores the importance of a more critical, reflexive, and inclusive approach to engineering education and knowledge creation, including the application of Artificial Intelligence, to ensure that diverse perspectives and ideas are considered in the creation of solutions to societal challenges.

Here I am motivated by the question of how engineering exists in contemporary society and how it influences our perceptions of human identity. I argue that our reliance on naming and measuring things that are otherwise invisible has created a situation where faith in a narrow field of science not only limits our understanding of phenomena but also creates a situation where we can more easily be remade. And I contend that the narrowing of our knowledge systems, despite the increasing progress of our technoscientific society, has made entities like Artificial Intelligence easier to create.

1.1 Engineering the Body, Mind, and Soul

Jonathan Swift's novel, Gulliver's Travels (1726), conveys several underlying messages and themes that connect well to Westernized[1] ways of social thinking and conduct, especially in relation to colonialism and imperialism. These messages include ideals related to colonization, social disciplines, and rational ways of knowing. As Lemuel Gulliver travels about, he discovers peoples of differing lands which hold a mirror to colonizers themselves. One such encounter involves the rational and sage Giants of Brobdingnag who reflect an air of cultural superiority over all others employing their knowledge and singular-minded approach to problems. Another encounter involves the Lilliputians and their obsession with social power and suspicion of Gulliver who had to prove himself useful to be accepted. This reflected the way in which colonizers finally accepted indigenous people based on their own terms of usefulness. A third encounter had Gulliver meeting a population of rational and virtuous horses who shared a land with the savage Houyhnhnms and Yahoos, a message that pays homage to the categorization and "othering" of those deemed irrational. Lastly, Gulliver meets two different groups of scientists, the astronomers of Laputa and the projectors of Balnibarbi. While the astronomers focused on

[1] I use the adjective "westernized" rather than "Western." Westernized thought refers to how Western ideas have been exported and adopted in other parts of the world, often with significant modifications to suit local contexts. This has been driven by factors such as colonialism, globalization, and Western-style education and cultural values spreading. One of the differences between Western thought and Westernized thought is their approach to cultural diversity and difference. Western thought is often criticized for universalizing and homogenizing knowledge, applying its own values and assumptions to other cultures and traditions. Westernized thought, on the other hand, seeks to incorporate and adapt different cultural perspectives and ways of knowing, recognizing the value of diversity. Another difference is their approach to the relationship between knowledge and power. Western thought prioritizes certain forms of knowledge and expertise, often excluding other forms and ways of knowing. Westernized thought challenges these hierarchies, promoting an egalitarian and inclusive approach to knowledge and understanding.

impractical abstractions of science, the projectors, whose use of technology produces numerous contraptions, also failed to meet the needs of society building dangerous and useless machines. This encounter is said to focus on the progress of science and technology without social implications to frame the ways to make them useful to man. Overall, the story of Gulliver's Travels is a critique of human pride and folly in relation to imperialism and the impacts of colonization.

However, one no longer needs to travel to witness occupied modes of existing. Westernized ways of doing, being, and engaging have been dominant for some time. As such, we are numbed to the control of body, mind, and soul. A rationalized society, or one which creates, frames, and reveres its own ontologies and epistemologies based on enlightenment canon[2], has managed to pull together the knowledge of science, the apparatuses of technology, and the utility of engineering to define not only the material world but also the non-material world. Emotions, attitudes, outlooks, and hopes have fallen under the control of the rational. However, this does not occur in isolation or at the whim of some powerful dictator. This change happens as a result of power and as it moves through society and the ways in which it disciplines individuals and populations. While science and technology moved society into what many consider to be a modern era, engineering would play an essential role in the disciplining of bodies, minds, and souls across space and time. This disciplining occurs in shifts in power relations and social normalizations.

[2] This includes rational ways of knowing and reliance on the connections between science, technology, and engineering.

Engineering, and the engineers who practice it, have played a significant role in shaping our society through their mastery of natural elements and the trust and admiration they have earned. In addition, their practical methods, standards, and mindsets have made them invaluable members of a society that values militarism, industry, and domination. However, there are questions about the impact of these ideas on marginalized communities, where irrationality is often seen as a barrier to progress. Moreover, as technology advances and concepts like cybernetics and artificial intelligence become more prominent in society, there is a growing concern about the impact of these artificial constructs on the human mind.

From this point of view, I offer this dissertation with two goals. Firstly, to expose the ways in which engineering has influenced our thinking, planning, knowledge creation, and method design. Secondly, to encourage educators to critically examine the narrow view of engineering and to create a more inclusive and reflexive approach that recognizes the diversity of human experience. Challenging dominant narratives and ideas can create a more objective understanding of engineering and its role in shaping society.

This dissertation is about the power of knowledge. Specifically, it is about the power accessible to teachers. In actuality, it is about how engineering exists in our present world and the ways which the engineer is formed. It draws from and considers a variety of methodologies, philosophies, and rationalities surrounding the existence of the engineer and engineering. This analysis is done on purpose. While this delves into slices of the history, anthropology, and educational praxis of the engineer and the act of engineering untangles truths and norms of the entity, it is not the singular focus.

1.2 A Narrative of Some Theoretical Frames: The Legacy of Sir Isaac Newton and the Origins of Modern Engineering

Arrogance, fear, and contest often force a desire or even a compulsion to know, name, and explain. Methods and systems formed from rationality and scientized[3] entities became paramount in quelling the uneasiness of the unknown, at times with miraculous outcomes and at others with rickety theories and methodologies. Scientization refers to the phenomenon of reducing social occurrences to exclusively scientific concepts and methods without acknowledging their cultural, social, or historical backgrounds. It implies that scientific reasoning has become the prevailing approach to thinking and decision-making in contemporary society, overshadowing alternative forms of knowledge and values. In this context, I urge educators to expand their understanding, question their assumptions, and embrace discomfort as they explore their own beliefs and emotions. Unknown things that are named and cemented in our disciplines. Unravel assumptions about the naturalized[4] world. Unlearn words that do not clarify experiences. While the engineer (in a general sense) and the teacher work wonders, both clutches tightly to rickety theories and methods stabilized utilizing apperceptive knowings, assumptions, and normalizations based on scientized efforts to make the invisible visible. This dissertation leaves this engineer-to-teacher metaphor in a form open for interpretation and inference. I hope there will be some ways in

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[3] Jürgen Habermas, the German sociologist, introduced the concept of "scientization" in his book "Toward a Rational Society" (1968). Habermas posits that the pervasive influence of science in social life has resulted in the subjugation of the lifeworld by the system, where individuals are viewed as mere objects of technological and bureaucratic control rather than as independent agents who possess the ability to establish and maintain significant social connections.

[4] The concept of nature as a social construct proposes that our perception of it is shaped by social, cultural, and historical factors. It implies that what we consider "natural" is not inherent, but a human interpretation. Therefore, approaching nature with an open mind and curiosity towards diverse ways of understanding and experiencing it is crucial.

which the discipline of thought and rationality look eerily strange in their resemblance. It is in this space that I present a representation of how the engineer and engineering exist as well as a model or method which I hope is accessible and helpful to educators to open the possibilities of thinking about different subject matter with respect to things like histories, philosophies, anthropologies, and materials and how these ideas intersect with educational set pieces like science, technology, engineering, and mathematics (STEM).

Finding a figure more influential to modern engineering than Sir Isaac Newton would be difficult. Amongst other discoveries and concepts, Newton's Laws of Motion and the theory of universal gravity changed the way the world was observed, measured, and integrated into practices of practicality. These discoveries created a form of influential and trustworthy [5]reasoning where the power of rationality and mechanical understandings and modelings [6]would take prominence over the mysterious and traditional. Newton's work put forth to the masses a belief system grounded in reason, empiricism, and rational inquiry, all of which make up the foundation of modern engineering and how we understand the engineer in the present. Newton's contribution to new ways to see and organize the world became fundamental to secular Enlightenment thought and the prevailing religious dogma of man's dominion over creation. The desire for practical and useful solutions employing engineering methods and the resolve to

[5] Newton's contributions to science, specifically his laws of motion, are crucial to comprehending how forces impact objects and are crucial to creating structures, machines, and other mechanical devices. Additionally, his investigations in optics, including discovering the spectrum of light and the principles of refraction and reflection, were significant in advancing the field of optics and creating lenses and other optical equipment.

[6] Take for instance automata. Automata refer to self-operating machines or mechanical devices that perform a series of predetermined actions or movements in response to a specific input or set of inputs. These devices can be powered by various means, including mechanical, hydraulic, pneumatic, or electrical power, and can be designed to perform a wide range of tasks, from simple repetitive motions to complex movements and operations.

control the naturalized world has taken many forms over time and space. However, some underlying features help unite an engineering type that entices by demystification and domination over all that exists.

The influence of Newton's legacy on society's trust in scientific methods cannot be overstated. During the Enlightenment, rationalists stressed the importance of science in explaining natural phenomena and expanding its applications through engineering and technology. This change led to practical experts, like modern engineers, who possessed significant knowledge in their respective domains. Moreover, as societies became more intricate, people increasingly relied on experts to make rational decisions based on proficiency. However, this reliance on expertise can be precarious, especially in societies rife with misinformation. Rose et al. (2006) argue that Latour's concept of expertise suggests it can morph into a transmutable and mobile form that shapes societies beyond their origins with no recourse for intervention or repression. This observation emphasizes how expertise can exert a powerful influence on shaping societal norms and values, with both positive and negative implications.

Newton's discoveries mystified and demystified natural phenomena, fostering trust and understanding among those who could comprehend his work. Likewise, his contributions to a practical science, including engineering, were instrumental in the progress of Westernized nations in domains like warfare, industrialization, and societal infrastructure. Nevertheless, the debate continues whether science education should prioritize appreciation or practicality and function.

To call what one might consider pre-engineering[7] practices and dominionism, new concepts would ignore scores of non-Westernized evidences of technology and power of premodern times. In the present, assumptions of dominance, dark ages, and novelty related to ideas and methods are often obscured by what Lupinacci et al. (2018) refer to as a "root metaphor" or an obscured form of influence or power which is "taken for granted." For a proper analysis, it is essential to unearth these roots so that we may better understand the diverse narratives of the action of engineering and the engineer. However, first, it is essential to understand modern engineering and the origin story of the modern engineer. This story begins with Newton.

Part of what Newton accomplished was to develop an authentic way to organize science and technology knowledge. These accomplishments helped to create ways of organizing and thinking that tethered together science, technology, and engineering and distributed them across time and space through sociopolitical power. Newton's implementation of mathematics would prove vital to the empirical reputation of engineering and would be necessary for validating its methodologies. Quantification would become important to methodologies involving measurement, assessing, and sorting materials in the physical world. As engineering became the preferred tool of science-like pursuits, its methodologies would become critical to creating and measuring things that are ethereal, often human, and often made of concern. Through the engineer and the adoption of engineering methods, mindsets, and practices, man's dominion would extend not only externally beyond the body and towards the infinity of divine creation but also inwardly deep into the bodily container of the mind and soul.

[7] I use this term as a way to draw attention to the actions of the engineer which occur prior to the nomenclature of the engineer as well as those who carry out similar tasks but are marginalized through a Westernized lens.

The concepts of modern engineer and engineering are rooted in 17th-century Enlightenment thought, Westernized civilization, and the rise of modern[8] science. In the modern form, these concepts remain rooted in and linked to an acceptance and trust of rational thought. Modern society holds to the truths of rationality and that phenomena of the observable world, and later the unobservable world[9], behaved according to rational laws which have the potential to be understood, defined, and manipulated using reasoning and observation. Rationality would serve as the foundation for advancing science, technology, and engineering. Nevertheless, what is rationality in this context?

1.3 The Unstable Nature of Rationality in Knowledge-Making Systems

Rationality is defined by the deployment of such concepts as logic, reasoning, and the use of evidence to generate knowledge, create belief and function assemblies, and problem-solve. It involves analytical and systematic approaches to generate understandings of the world around us. Rationality validates a scientific view in which any and all phenomena are explainable by employing scientific methods and technologies. This view opposes irrationality, where knowledge and reasoning are more often considered based on reflexive, reactionary, and emotional reactions. In comparing rationality and irrationality, one might notice the role of

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[8] My view of modern science throughout is based on Bruno Latour's writings. Bruno Latour posits that modern science is a social process involving the collaborative construction of knowledge through human and non-human agents. The production of scientific knowledge is a complex network of relationships between scientists, instruments, technologies, institutions, and other actors. In his book "Science in Action: How to Follow Scientists and Engineers Through Society" (1987), he argues that scientists are not just passive observers of the natural world, but actively construct it through different instruments and technologies.

[9] An example might be speculative realism. Speculative realism is a philosophical movement that emerged in the early 21st century. It rejects traditional philosophical and scientific assumptions based on anthropocentric or idealist principles. It emphasizes the importance of scientific inquiry while rejecting the idea that human cognition is the only means of understanding the world. Instead, the movement focuses on "the realism of the outside," referring to the existence and nature of objects and phenomena beyond human perception or comprehension.

objectivity in the differences. While the rational seems objectively reasonable compared to the irrational, bias remains. Rationality becomes positioned to decide objectivity and reason without itself coming under scrutiny. Since social and cultural norms can shape what is reasonable and objective, rationality is not, in itself, a stable entity—for instance, educational differences and their influences on how events are described, and experiences are shared. While certain ways of describing and experiencing the world are essential to consider in the judgment of rationality, the persistence to ignore or even change such means by influential colonizing entities like colonial schools become ways of sorting rationality and irrationality (Kirchgasler, 2019). Thus, rationalization becomes a technology of oppression used by colonizers to subjugate and exploit indigenous people whose perceived irrationality recreated them as inferior.[10] Norms conveyed in schools and other social institutions are modeled in hopes of disciplining and sorting individuals to act, decide, think, respond, and believe in a collaborative manner. While such categorizations are most apparent in colonized lands, assumptions of rationality occur in an abundance of interactions. These prevailing assumptions have created a level of trust and common sense amongst many Westernized scientists, politicians, and populations while creating the abject, the savage, or the mad.

As an unstable form, rationality is applicable to other forms of scientized disciplines, such as social and economic systems—this reforms rationality as a virtue. For instance, the capitalist system in the United States incentivizes particular "rational" actions connected to efficiency,

[10] To view non-Westernized cultures as "savage" or inferior is a result of Eurocentric thinking that equates rationality with modernity and Western-style reasoning. This narrow view suggests that cultures without Western advancements lack logical thinking and decision-making, relying instead on superstition. However, this perspective ignores non-Westernized cultures' complexity and sophisticated forms of thinking and decision-making. It also fails to acknowledge the influence of cultural context on rationality, as different cultures may prioritize diverse values or ways of thinking leading to varied forms of rationality.

maximizing profits, and minimalizing costs, no matter the context (social or environmental impacts, for example). Likewise, rationality in social systems like democracy includes such features as open dialog, evidence-based policymaking, and accountability. However, like the term "rationality" itself, multiple influences define cultural and social difference-makers, such as whose dialog, what counts as evidence, and who is held accountable. One can also witness partiality in rationality in the form of entities like confirmation bias and framing effects.[11]

Modern views of rationality and institutions often produce unintended or malicious consequences.[12] Such consequences often involve problems related to inequitable hierarchies, the exclusion of different voices, and the marginalization of particular ways of knowing. For example, Westernized models of engineering often rely on precise measurements, modern technologies, and hierarchical approaches. Such methods and knowledges may not be compatible with others who look to different cultural knowledges, traditions, and values to solve problems. For instance, Jardine & McCaffery (2013) explore the ongoing tensions between rationality and spirituality in a post-enlightenment world. They argue that while rationality has been a successful[13] quality within the trajectory of the Westernized world, it has also led to a fragmentation of knowledge, a disconnection from the naturalized world, and a marginalization

[11] Confirmation bias describes the inclination of individuals to search for and interpret information that aligns with their current beliefs or hypotheses while disregarding or rejecting contradictory information. Framing effects, on the other hand, refer to how the delivery of information can influence how individuals perceive and assess it.

[12] Additionally, the emphasis on technical expertise and quantitative analysis can sometimes result in a narrow and reductionist view of the world, which may not fully capture the complexity of social and ecological systems. Many consequences of Westernized models of engineering involve issues related to unequal hierarchies, exclusion of diverse voices, and marginalization of alternative ways of knowing. Precise measurements, modern technologies, and hierarchical approaches may not be compatible with different cultural values, traditions, and knowledges used to address problems. Jardine and McCaffery argue that environmental degradation, social inequality, and disconnection from the natural world are significant issues humanity faces today.

[13] Concerning science, technology, medicine, etc.

of spirituality. In the following chapters, I will introduce two engineer-adjacent groups whose traditional styles and non-conformity to modern engineering methods and technologies slotted them lower in production hierarchies, one within a nation and the other within a global valuation. The first group comprises the independent French weaponry artisans, whose traditional modes of craftsmanship were sidelined in favor of an innovative, comprehensive, and rational engineering system. The second group is the Bricoleur and comprises the subjects of research performed by anthropologist Claude Levi-Strauss. The Bricoleur produces with a commitment to ritualistic, spiritual, and cultural guidance as opposed to the rationality of the engineer.

In order to make science a practical and actionable form of knowledge-making, it required a primary set of rules or methods to ground its sensibilities in its principles. While the scientific method has been transformed, reformed, and deconstructed throughout space and time, it does prove to be an essential tool in validating science as a form of epistemological technology[14]. That is, it creates an air of scientific rationality which, when infused into knowledge-making systems, helps substantiate claims despite any impurities caused by certain contextual factors such as social or political influences. However, when social and political factors are ignored, knowledge and power become technologies of subjugation and hierarchical systemizations.

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[14] The epistemology of engineering differs from that of science or technology in three ways: it is focused on practical applications, is interdisciplinary, and emphasizes the design and creation of artifacts. The epistemology of engineering places a greater emphasis on the role of the engineer as a practitioner responsible for applying knowledge in the creation of technology and systems rather than as a scientist primarily concerned with understanding natural phenomena. The engineer must consider the practical limitations and constraints of the natural world and must make decisions that are informed by both scientific knowledge and practical considerations. This idea is a widely accepted perspective within the field of engineering, which has been developed over time through the work and writings of various scholars and practitioners.

In this book, Habermas (1968) argues that the scientific method is not a neutral or objective way of acquiring knowledge but rather a product of historical and social forces. He points to the weakening of the scientific method concerning social sciences and how systems and policies are affected by a scientized form of methodology that validates power impositions while ignoring cumulative sets of factors. This weakening leaves open opportunities to sort and categorize individuals in society with a false technology of validation and objectivity. However, this is not just a problem of the social sciences.

Latour & Woolgar (2013) offer a view of the entrenchment of social and political influences of science and its falsehood of objectivity. In "Laboratory Life," Latour & Woolgar (2013) point to a web of science whose every strand is contested by actors, institutions, funding, evaluation process, and communication outlets. A methodology has only a part of shaping science as the influence of power dynamics pushes the pursuits of knowledge in varying directions. This fact leaves scientific facts unfixed or immutable and open to contestation and negotiation within a sociopolitical realm.[15] This analysis is in no way a critique of the ways and means of science and the variety of methods it employs. However, it is crucial to recognize the impure form of science and its consequences on the derivatives of its methods, such as engineering and technological applications.

Despite the scientific method's amorphism and sociopolitical limitations, its framework has been used to organize ideas in engineering and technology. Because of its science and social roots

[15] An example is the concept of "Cultural Foundations of Crisis." This idea is that cultural factors significantly shape how individuals and societies experience, interpret, and respond to crises. It includes how different cultures understand the causes and consequences of crises, the values and norms that shape their responses, and how cultural beliefs and practices can facilitate or hinder crisis management and recovery efforts.

introducing several variables, an engineering methodology tends to be more challenging to confirm. Engineering methods tend to draw on simplistic rationality and abstract social goals creating a framework open to influence and determinism. For example, engineering methods tend to call for the concreteness of designs and materials while seeking out abstractions like optimizations and efficiency. By abstractions, I am referring to the measurement of a non-material entity which in itself is tethered to an excess of sociopolitical influences. This entity often grows from a method of reverse engineering to systematize abstract entities like efficiency and effort to form baselines and create ranges of acceptable norms. In the coming chapters, I use the term apperception to describe this methodology.

1.4 Apperception and the Mechanization of Society

In psychology, apperception is a term coined by Kant to describe how individuals use their existing knowledge and experiences to interpret and construct new understandings. In this dissertation, the term is used to describe a tool of design or engineering that transforms the intangible from various data points into a measurable entity, turning it into an object of concern, manipulation, or disability. This approach is often reflected in methodologies that involve large data sets and sociological and psychological designs derived from the scientization of these disciplines. Engineering and design are related fields that share similarities but have distinct differences. Engineering applies scientific and mathematical principles to develop practical solutions to complex problems, while design focuses on creating products, systems, and experiences that meet the needs of users or customers. In addition, engineers approach problems from a technical perspective, while designers take a user-centered approach.

Both engineering and design are critical in developing new technologies and products. However, the mechanization of society through these methods has led to the normalization of merging humans, engineering, and the material world. This process has led to the mechanization of thoughts, emotions, and reactions and the reduction of non-material entities to numbers, programs, and algorithms. The engineer has become the problem solver of society, and engineering methods have found new and strange applications fueled by trust in science, technology, and engineering. This concept has led to a search for problems to be engineered in both the material and non-material worlds.

Additional engineering methods include actions and dispositions related to systemizations, practicality, analysis, management, causality, standardization, quantification, modeling, and controlled experimentation. In these, there is overlap with the purest form of the scientific method concerning analysis and experimentation. Nevertheless, engineering methodology works within a tighter framework because of its integration with sociopolitical demands. Engineers are seldom free to seek problems and solutions but are bounded by sociopolitical influences, organizational standards, and progressive pursuits (March, 1994). This last restriction often blurs the boundaries of science, engineering, and technology, forming new ties between the human and technical realms.

Engineering has played a significant role in progressivism by acting as a codependent driver along with technological and scientific advancements. Such advancements have been looked upon most favorably by Westernized nations and the well-being of the influential in those societies. Of course, this view becomes problematic as one shifts from a Westernized view to a more Cosmopolitan[16] approach (Popkewitz, 2012). Popkewitz's argument in education is that a cosmopolitan approach challenges the traditional Western-centric practices and knowledge in schools. This approach values diverse perspectives and experiences, promotes an inclusive and global understanding of knowledge, and emphasizes intercultural dialogue and diversity. Popkewitz's work on cosmopolitanism in education illustrates the complex relationships between education, culture, and politics in a globalized world.

However, there are also challenges and limitations of cosmopolitanism in education. For example, emphasis on cultural diversity and recognizing different perspectives can lead to a relativistic approach to knowledge and truth. Furthermore, implementing cosmopolitan ideals in schools can be complicated by political and economic factors such as neoliberalism and globalization. Therefore, a shift from dominant Western-centric methods to a more inclusive approach to identifying and solving problems is needed. This shift would promote diversity and inclusion, widen the scope of ethical decisions and impact analysis, and impact questions regarding autonomous weapons, data misuse, and technological surveillance.

Some additional entities connected to progressivism and the role of the Science, Technology, and Engineering assemblage[17] (STE assemblage) include matters of dominance on many levels.

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[16] The concept of cosmopolitanism highlights the philosophical and social interconnectedness and interdependence of human beings across various cultures and nations. It advocates for the notion that every person bears a collective obligation to advance global justice and pursue the greater good.

[17] Here I use the term "assemblage" to refer to Deleuze's theoretical framework, which emphasizes the concept of an entity composed of multiple elements, including people, objects, and ideas, that come together to form a complex system. Assemblages are dynamic and constantly changing, as the relationships between the elements within them shift over time. Legg (2011) argues that the concept of assemblage can be used to understand the workings of power and the production of space. By focusing on the relationships between different elements within an assemblage, it is possible to identify the power dynamics at play and the ways in which different actors and practices contribute to the shaping of space.

Take, for example, the national Manifest Destiny and American Exceptionalism ideas. Manifest Destiny involved the will of numerous 19th century Americans' desire to stretch their land holdings from, as it was written, "sea to shining sea.[18]" Applied technologies like the steam engine and the telegraph made this desire into a material reality while racialized scientific theories like Social Darwinism created a justifying conviction. Likewise, American Exceptionalism as an outgrowth of such an attitude was expanded by means of new forms of infrastructure, military, and computerized technologies incorporating new ways to racialize and genderize engineering. Genderization and androcentrism[19] would also play a part in the home as new technologies geared towards the femininized role in the home were often designed and engineered by men. This perception includes the 19th-century male-centered designs of the corset, a device to shape the female form, and the handheld massager, a device to used treat female hysteria and "wandering womb." The latter creation exists in the present as the personal massager or the vibrator. From these examples, one might notice that progress sometimes involves a certain level of denied atonement.

[18] The line "from sea to shining sea" is from the patriotic song "America the Beautiful," which was written by Katharine Lee Bates in 1893

[19] Androcentrism refers to a perspective that places men and masculinity at the center of society, culture, and history while relegating women and femininity to the margins or excluding them altogether.

1.5 The Intersection of Science, Technology, and Engineering in Technoscience: Implications for Society

Progressivism, based on the interplay of science, technology, and engineering created a system of integration Latour (1986) refers to as a technoscientific life or technoscience. [20] Technoscience describes the merging of technology and populations in order to create assemblages which, over time and space, have become difficult to unravel due to the complexity of the assemblages and their distributed nature across time and space. Science, technology, and engineering formed an assemblage from which each build and helps advance the other disciplines as time goes on.[21] As this assemblage continues to churn through space and time, one can witness the formation of countless knowledges, technologies, and methods, creating a vast web of entities. Their existence and progress have become ordinary. The engineer and the action of engineering using applied scientific knowledge and technology is an essential driver of the existence and progress of the present. As they create more complex systems each day, units of progress notch up to another level. Moreover, as they intrude on individuals, levels of consciousness come into question.

In today's Westernized societies, technology has become an essential aspect of people's lives, providing convenience, entertainment, security, and even a sense of prophecy[22]. Pierce (2012)

[20] Additionally, Kristin Asdal et al. (2007) argues that it is important to analyze the political dimensions of technological and scientific developments. The argument is expanded to include a wide range of topics including environmental regulation, biotechnology, gender and sexuality, and the politics of knowledge production.
[21] For example, Li (2018) has emphasized the importance of interdisciplinary collaboration between STEM fields and other areas such as psychology, linguistics, and neuroscience for developing more advanced and human-like AI.

[22] Engineers are often viewed as prophetic due to their ability to predict future technological advancements, identify potential problems before they occur, and develop innovative solutions to current problems.

notes that the convergence of science and technology is essential for societal progress, including addressing physical security threats and economic issues. Science education now includes teaching engineering and technology alongside the natural sciences to better understand the designed world (National Research Council of the National Academies, 2012, p. 121-122). The National Academy's frameworks emphasize the need for science workers in economic and social futures and use the term "technoscience" to highlight the urgency (National Academies, 2010, p. 122).

Engineering frameworks play a crucial role in shaping society's approach to progress, learning, and problem-solving. Engineers design mechanisms that follow the laws of nature and provide solutions in various areas. However, the creation of engineers is an engineered process, and the codependence between technology, science, and engineering is central to progress. Unfortunately, this codependence also has the potential to create a dehumanized existence that blurs the lines between material technologies and the human body, mind, and soul. While this cyborgian existence may seem far-fetched, it is essential to consider the implications of this merging in future discussions (Pierce, 2012).

To better understand the relationship between technology and society, this dissertation draws on various theories that attempt to level the playing field between human and non-human actors. One such framework is Actor-Network Theory (ANT), developed by sociologists Bruno Latour (1986) and Michel Callon (1984), which proposes that social reality is shaped by the interactions between human and non-human entities, all of which have agency and importance. This approach expands our understanding of the potential power dynamics in relationships between humans, technology, and society. Additionally, Haraway's (2006) Cyborg Manifesto provides a way to consider the integration of technology with the body, mind, and soul without the complexities of prior sociopolitical influence. This vision helps to remove traditional dualities and opens up the possibility for an uncategorized and adaptable subjectivity. Both ANT and Haraway's Cyborg Manifesto provide ways of thinking about technoscience beyond traditional power structures and biases and allow for a more fluid and inclusive understanding of the relationships between humans and technology.

Unchecked technoscientific expansion and societal trust in science not only have the potential to create specific types of individuals through the STE assemblage authorized by a technoscientific trust but have also influenced specific exclusionary methodologies. The influences of engineering systems have extended from the material to the non-material. Understanding an entire engineering system is difficult, but we can identify certain patterns, such as engineering methodologies, quantifications, and standardizations. It is critical to recognize that the concept of engineering has infiltrated various institutions, including biology, genetics, medicine, computer science, data control, programming, and education. Jasanoff (2015) notes that networks can obscure responsibility and depoliticize power by rendering actions opaque or invisible. To address this problem, political theory should be applied to network analysis. Latour's (1986) ANT and his concept of the Immutable Mobile [23]explain that an object, document, or idea can be

[23] According to Latour (1986), an "immutable mobile" is formed by a complex network of various elements, such as people, instruments, texts, and institutions, which converge in a specific context to generate a particular scientific claim or discovery. The term "immutable mobile" refers to those elements that have the ability to spread widely and become accepted as part of scientific knowledge, despite being removed from their original context of production. Latour argues that the circulation of immutable mobiles is essential for establishing and maintaining the stability of scientific knowledge, enabling scientists to communicate their findings across time and space and to build on the work of others. However, he also highlights that the meaning and significance of these elements can

transported into different contexts without losing its meaning or identity. According to Latour (2011) the diffusion of scientific concepts is facilitated through the production of inscriptions that reduce and simplify the complexity of the world, creating "immutable mobiles" that can be transmitted by centers of calculation to link actors and actions that may be far removed from the original site of production.

Engineering systems as an immutable mobile creates a need to rethink the distribution of authoritative power tied to science in the form of scientization, but to also include the STE assemblage partners in the form of engineerization[24] and Technologization[25] (Lee, 2019). In considering engineering as an Immutable Mobile, one can better see the potential for engineering and its practical roots in creation and design offer a way to problem solve beyond the material world. In the physical world, engineers rely on the understanding of materials and the ways they must be shaped, measured, cut, joined, harmonized, and integrated into systems. Again, many of these ideas form from the identity of the system of engineering based on methods, quantifications, and standards. However, as these ideas are applied to non-material or the

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vary depending on the social and historical context in which they are deployed. Therefore, scientific knowledge is always subject to revision and reinterpretation, as new contexts and perspectives emerge.

[24] Engineerization can be understood as the process of using engineering principles and techniques to solve complex problems in various domains, such as science, technology, industry, and infrastructure. It can also refer to the growing influence of engineers and engineering organizations in shaping public policies and decisions related to technology and innovation.

[25] Technologization is a sociological term that describes the increasing dominance of technology in modern life. It involves growing reliance on technology and the belief that technological progress can solve societal problems. This trend is evident in the increased use of digital technologies, automation, and artificial intelligence in various domains, including work, education, communication, and entertainment. Technologization strives to make everything more technical and reliant on technology. However, this approach has faced criticism for dehumanizing social relations, eroding privacy, concentrating power in the hands of a few tech giants, and marginalizing people who lack access to or proficiency with technology. Critics advocate for a more critical and ethical approach to technology development and use.

abstract, a wonderous and potentially dangerous phenomenon occurs as the unseeable is made visible. Methods, quantifications, and standards come together in scientifically validated (or more specifically engineerized and technologized substantiations) designs to help make visible the invisible by designing ways to define and count it, measure it, and grade it on newly formed scales, and to correct variances. This way, apparitions and abstractions could join the material world as things of concern to be named, measured, and controlled.

Take, for instance, the idea of social engineering. The term “social engineering” was first used by economist and sociologist Thorstein Veblen in the early 20th century and related to scientized ways of disciplining human behavior employing various forms of social organization and manipulation. Some examples of social engineering in the United States included eugenics, a selective breeding initiative that identified and measured individuals based on phenotypical expressions, universal education that helped (and still helps) to measure and sort children into various levels of literacy and abilities, and urban planning which shaped cities impacted individuals based on desired racial, cultural, and economic outcomes. In these examples, there seem to be underpinnings of sociopolitical influence related to hierarchical structures, economic pursuits, and democratization. Westernized obligations to particular work ethics and production ideals often stem from religious doctrine (Weber, 1905). The idea of efficiency also produces time-saving measures in order to provide more leisure and play time around a busy work schedule. In a society that values work, rugged individualism, bootstrapping, leisure, play, and freedom, the engineer provides products and methods considered valuable to the modern family and the hope of the "good life" and shapes progressive interests (Popkewitz, 2012).

An assemblage formed from sociopolitical, economic, and democratic pursuits joined in conjunction with social engineering would help to produce the progressivist pursuits and ideas that drove industrialization and urbanization. Such ideas exist in a variety of modern discourses. Industrialization and urbanization, in themselves, integrated forms of scientization, technologization, and engineerization through scientific management schemes focused on bodies and populations both within the factories and within the cities. As mentioned above, urban planning as a form of social engineering became a way to weaponize science through social power structures designed to oppress and marginalize certain groups. Through the authority of science, such actions were not addressed meaningfully based on current political discourses.[26] But engineering acts on the powers of multiple engines. Where do the other controlling factors of bodies and populations lie?

1.6 The Interplay of Biopower, Engineering, and Governmentality: Foucault's Perspective

Foucault's (1975) concept of "biopower" refers to how power is exercised over individuals and populations through the use of technologies and techniques, such as medicine, public health, and surveillance, to regulate and control the biological and social processes that shape human life. Biopower manages and optimizes life, health, and well-being and standardizes bodies, behaviors, and identities.

[26] For instance, the Republican criticisms of the current United States Secretary of Transportation, Pete Buttigieg, and his comments concerning racialized highways were called into question. Buttigieg has brought attention to the racist history of highway construction in the United States. Buttigieg has highlighted that many highways were constructed in the mid-20th century in predominantly black neighborhoods, causing displacement of residents and disruption of local economies. This phenomenon, called "highway construction and urban renewal," was often driven by racist policies such as redlining and segregation, which aimed to concentrate people of color in specific areas and restrict their access to opportunities. Buttigieg acknowledges the long-lasting impacts of these policies on affected communities and has pledged to address them through infrastructure investments and other policy initiatives.

Biopower operates at both the individual and collective levels and is intertwined with broader social and political structures. Foucault's (1975) concept of "biopolitics" extends biopower to the level of populations and focuses on the ways in which power operates on the biological and social processes that shape human life. Biopolitics is concerned with managing and optimizing life, health, and well-being at the population level and constructing norms and categories defining who is included and excluded from the political community.

Engineering has played a significant role in the development of biopower technologies, including medical and biotechnological devices that monitor, diagnose, treat diseases, enhance performance, and extend life. However, engineering has also contributed to the development of technologies used to regulate and control populations. Taylorism is an example of biopolitics, a set of scientific management techniques developed in the late 19th and early 20th centuries aimed at increasing productivity by breaking down complex tasks into simpler, more repetitive motions that could be standardized and controlled. This change gave employers greater control over their workers, resulting in a decrease in their autonomy and an increase in disciplinary measures and surveillance.

As science, technology, and engineering advanced, new ways of surveillance and discipline emerged. Taylorism and Industrial Psychology became normalized practices of naming, measuring, and controlling bodies in factories and workplaces. Taylorism aimed to improve bodily efficiency and productivity by breaking work down into smaller measurable and assessable modules, monetizing worker outputs, and forming a value system based on body systems. Industrial psychology is aimed at the mind and soul, quantifying non-physical creations such as aptitude, personality, and attitude. This engineering and design rely on analyzing the outcomes of surveys, interviews, observations, and experiments to create an image of the workers' non-physical entities as they are deployed within the workplace. These examples demonstrate disciplinary actions on the body and mind based on engineering concepts that create social contracts or moral orders across various locations.

Industrial psychology is a tool of biopower and can be seen as a tool for the application of biopower to the management of human labor. The study of human behavior in the workplace optimizes and regulates work processes, a fundamental aspect of biopower. Industrial psychology provides disciplinary technologies of management and motivation to increase productivity and efficiency. This action leads to control of bodily movements, ways of thinking and acting, and ways to feel or interact beyond one's existence. Industrial psychology can be seen as a manifestation of biopolitics, which seeks to control and regulate human life in the interest of broader social and economic goals.

The modern engineer and the action of engineering has become a respected and trusted profession uniting science and technology expertise[27] with practical problem-solving, pride, and efficiency. As civilizations grew increasingly complex and interconnected, specialized knowledge and technical know-how became increasingly important. Practical problem solvers were needed to control natural phenomena as well as safer progressions and persons. Soon,

[27] Expertise refers to the specialized knowledge and skills possessed by an individual or group in a particular field or subject, which can provide power and trust to engineers and engineering in modern times.

engineers became essential to a functioning society and found themselves entrusted with various responsibilities to create and manage stable, reliable, and safe systems. Effective use of such power would benefit many within such a society. However, it is essential to consider the engineer and engineering as entwined with societal and political influences, and with that, the potential of creating both the engineer and the non-engineer. Furthermore, since engineering is tethered to rationality, morality, and salvation, his place in society might be revered as what Popkewitz (2012) refers to as a “universal citizen.”

The universal citizen represents the ideal modern democratic citizen whose morals and values align with rationality, justice, and fairness but whose shortsightedness fails to acknowledge or entertain differences in the alignment of thinking, acting, and doing. With this problem, the person rendered the non-engineer has the ability to join the engineer if not through expertise and aptitude, then by reverence, acceptance, and moral allying. That is to form an a priori position on engineering model such behaviors as acting in the best interest of all people, having integrity, responsibility, empathy, diligence, and collaborative practices. However, as Popkewitz (2012) suggests such alliances might become tense under particular kinds of scrutiny. This categorization has the potential to not only "otherize" or socially alienate the non-engineer but also "otherize" the non-engineer into a subcategory of the irrational, the conniving, or the savage.

Additionally, with the concept of the engineer as one who is always prepared, often utilizing prophetic influence to predict futures and outcomes, the non-engineer non-conformist also has the potential of being stigmatized as unaware, vulnerable, or in need of rescue. Institutions and governments join the expertise of the engineer in this kind of case to form anticipatory regimes or future-focused solutions to predictable problems. Commitments to future problems and existences again follow engineering methods through the naming of that which does not exist (yet), the measurement of that entity, and the means to control it. Moreover, ways to conduct oneself in the face of impending factors or to discipline preparedness come into play in governmentality, a concept of Foucault’s (1975) and closely related to biopower and biopolitics.

In Foucault's theoretical framework, governmentality, biopower, and biopolitics are interdependent concepts concerned with how power operates through various forms of governance. Governmentality refers to the techniques and strategies used to govern individuals and populations through the production and dissemination of knowledge, the construction of norms and values, and the regulation of behavior. Biopower and biopolitics are both aspects of governmentality that are concerned with the regulation and control of bodies and lives at the individual and population levels, respectively.

Foucault (1991) argues that governmentality operates through mechanisms of power such as discipline, regulation, and normalization, constructing norms and categories that define legitimate or deviant behavior and enforcing conformity to these norms. While governmentality is often associated with neoliberalism, Foucault emphasizes the importance of resistance and contestation, suggesting that individuals and groups have the power to challenge and subvert dominant forms of governance. Understanding these concepts provides insight into the complex ways in which power operates in modern societies and can help promote more equitable and just forms of social organization. For my analysis, I use the work of Rabinow & Rose (2006) and their definitions derived from Foucault’s work.

Rabinow & Rose (2006) contend that biopower is not merely a theoretical construct, but a practical reality that operates on the "plane of actuality." This plane refers to the concrete practices and technologies through which biopower is exercised, such as medicine, public health, and social welfare. Biopower regulates and controls life processes, body and population production, and management. By analyzing the plane of actuality, one can comprehend the complex and multifaceted ways in which power is exercised over human life in modern societies and identify possibilities for change and resistance. The plane of actuality is always subject to transformation as new technologies, ideas, and social arrangements emerge, and old ones become obsolete. The plane of actuality is also used to describe the realm of possibilities within a particular historical moment, shaped by a set of technologies, practices, and discourses. This concept helps to understand how historical context shapes what is possible or impossible within a specific period.

Rabinow and Rose's concept of biopower are closely related to governmentality, as it refers to the ways in which power is exercised over human life in modern societies. Biopower is concerned with the regulation and control of life processes, body and population production, and management and operates through a range of practices, including medicine, public health, and social welfare. In this sense, biopower can be seen as one of the techniques through which modern states govern their populations. By regulating and controlling the lives and bodies of their citizens, states are able to maintain social order and stability, while also pursuing various political and economic agendas.

The concept of the plane of actuality is also relevant to governmentality, as it highlights the importance of understanding the specific historical context within which power is exercised. By analyzing the concrete practices and technologies through which biopower is exercised, we can gain insight into the ways in which power is exercised over human life in a particular historical moment and identify possibilities for change and resistance.

Governmentality and biopower are closely related concepts that help us understand the complex and multifaceted ways power is exercised over human life in modern societies. The concept of the plane of actuality is a valuable tool for analyzing and intervening in contemporary social problems by highlighting the specific practices and technologies through which power is exercised and the possibilities for change and resistance that exist within them.

1.7 The Complexities of Modern Engineering: Expertise, Power, and Perceived Responsibility

Discourses surrounding the modern engineer often go beyond scientific aptitude and technical skills. Often there are hints of systems of values, beliefs, and morals that are communicated. Mentions of the discipline of the engineer, engineering mindsets, and the engineering spirit may bring to mind assumptions of practical, objective, rule-following, creative, virtuous, and loyal to the plan. One can assume these might be related to the imagery and authority engineers hold in society, but it also connects to the power and potentials of systems they create and control. Engineers shape the naturalized world into a human-centric form. The reciprocation for meeting the needs and desires of the people is a predisposition of trust and indebtedness. In order to gain this level, the engineer must achieve, live up to, and protect standards of expertise, institutional authority, and cultural and economic influences, all of which, as we may have noticed to this point, are unstable entities with varying exchanges of influence.

The modern training of the engineer again incorporates a series of complex assemblages, all of which are influenced by a vast number of entities. Imagine having dominion over the space where mathematics meets physics, meets computer science, meets technology, all of which are manipulated to create systems defined by politicians, societies, industries, and educational entities under the tenants of rationality, efficiency, and precision. The engineer's expertise consists not only of the navigation of science and technology but also of a social and abstract world. As a profession, engineering is regulated through a rigorous set of standards, licensing, and certification programs that provide their own methods of inclusion and exclusion. Inclusion, in this case, means power. While these discourses provide a normalized view of the responsibilities and values of the engineer, it is important to think about the influences such power has on society as a whole concerning inclusive, ethical, and justifiable decisions.
Power is not merely based on the body, mind, or soul, but on the histories, expertise, and reputations of the engineers before.

Therefore, with expertise and authority come several imposed and different ways to work within the STE assemblage. Responsibilization promotes individualistic values and techniques such as self-help and self-regulation to make individuals feel responsible for their own well-being and success. It reflects the power dynamics in modern societies and the need to understand governing techniques. Analyzing responsibilization offers insights into promoting more equitable and just social organization (Beck, 1992; Foucault, 2008; Rose; 1996). Such responsibility often makes for heroic story characters with the proverbial and mythological weight of the world on their shoulders, like Atlas (Theoi, n.d.). In books and movies, the engineer is often portrayed as an expert whose skills often save the day, the planet, or the like. However, their creations are not so nick of time in real life as they are just in time. That is to say, in Westernized societies, the engineer is looked to for just-in-time solutions to allow for progression regarding technologies and knowledge. The fulfillment of such needs creates value through advancements in medicine, industry, technology, etc.

1.8 The Complexities of STEM Education, Power, and Societal Norms: Creating the Engineer and the Non-Engineer

STEM education has become increasingly popular in recent years as a response to the growing demand for highly skilled workers in engineering, mathematics, science, and technology fields. However, there are criticisms that STEM education may not adequately prepare students for the real-world application of their skills and that it may not be reaching all students equally, with underrepresented groups such as women and minorities having less access to STEM education and opportunities. This has led to a growing body of research examining the role of education in perpetuating or challenging systems of inequality.

Scholars such as Pierre Bourdieu, Michel Foucault, and bell hooks have made significant contributions to our understanding of education and its role in perpetuating or challenging systems of inequality. Bourdieu's theory of cultural capital emphasizes the ways in which cultural knowledge and practices are passed down through families and social groups, creating advantages for some individuals over others. Foucault's work on power and knowledge in institutions highlights how educational institutions produce and reproduce social norms and power structures. Hooks' (2000) work on education and feminism emphasizes the importance of considering gender, race, and class in educational settings.

Yolcu & Popkewitz (2019) have contributed to the discussion on science education for abled and disabled individuals. They argue that the notion of a "mathematically able body" is a social construct that shapes the way individuals and others perceive and interact with the world. Their work highlights the ways in which ableist beliefs and practices are reinforced and reproduced in mathematics education, perpetuating the exclusion of marginalized groups from STEM education, and limiting their opportunities for success in these fields.

Yolcu and Popkewitz suggest that the choice or rejection reveals values. This point means that the ways in which individuals engage with mathematical play can reveal underlying cultural beliefs and values about what constitutes "ability" and who is deemed worthy of participation in mathematics education. By critically examining the underlying values and principles of STEM education, we can work towards making it truly equitable for all students and ensuring that it fosters the development of well-rounded individuals who are able to think critically about the ethical and societal implications of their work in STEM fields.

In conclusion, the role of rationality and scientization in society has been complex and multifaceted. On the one hand, the deployment of scientific concepts and methods has led to miraculous outcomes and advancements in fields such as medicine, technology, and engineering. However, on the other hand, reducing social occurrences to exclusively scientific concepts and methods has led to the overshadowing of alternative forms of knowledge and values, which can result in rickety theories and methodologies. Furthermore, the notion of rationality itself is not a stable entity, as social and cultural norms can shape what is considered reasonable and objective.

The merging of technology and populations has created assemblages that are difficult to unravel due to the interplay of science, technology, and engineering. This concept of technoscience has become intertwined with broader social and political structures, leading to the exercise of power over individuals and populations through the use of technologies and techniques. This exercise of power extends to the level of populations, leading to the construction of norms and categories that define who is included and excluded from the political community.

In the field of engineering, the engineer's expertise consists not only in the navigation of science and technology but also in a social and abstract world. The profession is regulated through a rigorous set of standards, licensing, and certification programs that provide their own methods of inclusion and exclusion. While these discourses provide a normalized view of the responsibilities and values of the engineer, it is important to consider the influences such power has on society as a whole concerning inclusive, ethical, and justifiable decisions. Ultimately, the role of rationality and scientization in society is complex and multifaceted and requires a nuanced understanding to navigate its complexities.

1.9 The Chapters

To fully comprehend the role of modern engineers in driving progress, it is essential to analyze engineering from various perspectives. This dissertation explores three lenses through which engineers can be understood: The Engineer as Hero, The Engineer as Myth, and The Engineer as Engineered. However, it is essential to note that reducing the engineer to a singular icon would be inappropriate. Instead, this work is guided by the concept of dynamic nominalism, which recognizes that concepts and categories transform and redefine over time as our understanding of the world evolves. Hacking's (1983) work on dynamic nominalism emphasizes the importance of comprehending the historical and cultural contexts that shape our concepts and categories.

The Engineer as Hero perspective has been criticized for oversimplifying and not critically evaluating the engineering profession. This perspective idealizes the positive impact of engineers on society while overlooking the potential negative consequences of their work. The Engineer as Myth perspective highlights the issue of arrogance and narrow-mindedness in Westernized society, leading to a lack of understanding and communication between engineers and non-engineers. Finally, the Engineer as Engineered lens underscores the critical role of education, training, and social institutions in shaping modern engineers.

A comprehensive understanding of the role of engineers in society requires a critical examination through multiple perspectives. Engineers must navigate the sociopolitical context, engage in interdisciplinary collaboration, and consider the social and ethical implications of their work. By acknowledging these perspectives and the concept of dynamic nominalism, we can better understand the complex relationship between engineers and the world around them and ensure a positive and sustainable impact on society.

In Chapter 2 of the book, the emergence of modern practical science and technology is examined, particularly in the context of the field of engineering. The focus is on the Gribeauval System, which originated in 18th century France as a military technique for standardizing and organizing human and non-human materials to enhance progress on the battlefield, as well as in areas such as economic securities and industrialization. The argument presented is that Gribeauval's approach, combined with emerging Enlightenment ideas and disciplinary methods, led to the decentralization of power and the emergence of favorable, progressive, and trusted institutions.

Engineering became a symbol of society's confidence in technoscientific discoveries and commitments, with the Modern Engineer developing into a problem solver utilizing techniques of control over the provisions of the earth, as well as the body, mind, and soul of man. Gribeauval's system influenced militarization and economization, resulting in a "technical life" dependent on technoscientific advancements. This established engineering as a critical component of national interests, contributing to its globalization and socio-political influence.

While acknowledging the potential for disrupting this cycle to consider alternative ways of thought that ignore those things deemed irrational, sentimental, or ritualistic, the impact of technology and science on engineering, specifically through the Gribeauval System, is highlighted. This transformed engineering from physical protection to technological form and led to the creation of a "technical life."

The chapter emphasizes the importance of critical evaluation of the engineering profession, acknowledging both its positive impact and potential negative consequences and the need for diversity and interdisciplinary approaches in solving complex societal problems. The historical context of engineers as heroes during the Industrial Revolution is explored, highlighting the underrepresentation of diverse perspectives and systemic biases in the profession.

By referencing historical context and scholarship, the chapter adds depth and nuance to the discussion of the Engineer as Hero perspective. It highlights the need for a critical evaluation of the role of engineering in society and for greater diversity and interdisciplinary approaches to address complex societal problems.

In Chapter 3 of the text, I delve into the notion of the bricoleur as conceptualized by anthropologist Claude Levi Strauss and its relevance to modern Westernized society's engineers. In the passage, I refer to the engineer as a myth to demonstrate the idealization of this figure in the Westernized scientific tradition, which associates progress with technological innovation. Although the engineer is often regarded as an ideal problem-solver, this perspective can be one-sided and overlook other innovative approaches to complex problems. The concept of the bricoleur challenges this ideal by employing unconventional methods and materials to achieve goals, relying on intuition, experimentation, and improvisation to develop innovative and unexpected solutions. The tension between the engineer and the bricoleur underscores the significance of diverse perspectives and problem-solving approaches. The bricoleur is perceived as a culturally constructed figure who operates as a type of engineer, employing methods and ways of thinking that are more culturally focused than technoscientific. The chapter's objective is to examine the engineer's role in a forward-looking Westernized society and how engineering has been utilized to develop methodologies and epistemologies for phenomena that cannot be detected through normal means.

The chapter delves into the emergence of governmentality and biopower, forms of disciplinary power that create and categorize types of people based on beliefs, epistemologies, and ontologies. Governmentality compels individuals to act by internalizing rationalities or regimes of truth that emanate from legal, health, or educational apparatuses of the state. Biopower, on the other hand, is a regulatory power that disciplines individuals in multiple ways, including through personal hygiene, self-care ethics, and morality. I also highlight the potential for arrogance and narrow-mindedness within Westernized society, which can create a divide between engineers and non-engineers and limit the perspective on the value of other disciplines in solving real-world problems. Two different perspectives on problem-solving and creativity, the bricoleur and the engineer, are introduced in this chapter, reflecting a larger power struggle over who has control over knowledge and the means of production.

Furthermore, the text examines how engineering design principles connect to forms of control that become commonsensical to the masses in a society looking to maintain its levels of progression and comfort. There are suggestions of Westernized superiority based on rational-looking applications or scientizations applied to unseeables, such as intelligence measured by IQ tests. These tools of categorizations have come back into favor under ideals of interest, persistence, and grit, which may normalize the unseeable to form it into a disciplinary technology, moving power imposed upon the body into the mind and soul.

Finally, the chapter explores Foucault's statement that disciplinary power controls and measures the body through its disciplining, optimization, extortion, and integration into systems of efficient and economic control. This form of power exists and functions at the will of the interface of science and society pushing towards the comforts and salvations of the greater good. As industrialization became the technoscientific norm of Westernized societies during the 18th and 19th centuries, man began his transformation into a machine-like entity complete with functions, utilities, inputs, outputs, disabilities, and precisions.

In Chapter 4, I explore the transformation of engineering into educational institutions and societal influences, focusing on the concept of childhood in the post-enlightenment era. This era saw the emergence of the child as a blank slate upon which knowledge, morals, and values could be written. However, this concept was also associated with problematic social theories such as recapitulation theory and developmental progression.

STEM education has emerged as a disciplinary technology that operates on the body, mind, and soul through engineering methods and standards, shaped by various influencers across different categories. While STEM education provides specialized technical skills, it can often neglect social and ethical issues. To address this, STEM programs need to balance technical skills with ethical education, promoting diversity and inclusion, and preparing students for global challenges while fostering ethical leadership.

Incorporating alternative approaches such as engineering methods, inquiry-based learning, and constructivism can also enhance STEM education. Research has shown that incorporating engineering methods into STEM education can lead to improved academic performance and increased interest in STEM fields among students (Bryan & Simmons, 2017; Lachapelle et al.., 2018). STEM schools should strive to provide a range of options based on individual needs and learning styles and emphasize the importance of hands-on learning opportunities.

The phrase "engineering the engineer" in STEM refers to designing and shaping the education, training, and development of engineers to meet specific goals. This includes incorporating interdisciplinary and liberal arts courses, hands-on learning opportunities, and promoting diversity and inclusion. "Engineering the engineer" emphasizes the importance of preparing engineers not just for technical competence but also as professionals, innovators, and societal leaders in the ever-evolving STEM industry.

Overall, the chapter highlights the importance of considering the societal and cultural context of STEM education and the need to balance technical skills with ethical education and diversity and inclusion efforts. It also emphasizes the role of alternative approaches in enhancing STEM education and preparing students for their roles as professionals, innovators, and societal leaders in the STEM industry.

Chapter 5 examines the growing importance of social engineering, particularly in the realm of digital technology and social media, and its ethical implications, such as privacy, manipulation, and consent. The concept of engineering the mechanical mind and soul refers to the application of mechanical technologies and algorithms to control and manipulate human bodies, minds, and even souls, which raises important ethical, philosophical, and historical questions. Michel Foucault's concepts of governmentality, biopower, and biopolitics provide essential insights into these issues, revealing how power operates through knowledge and discourses. The concept of biopedagogy emphasizes the role of education in the regulation and control of bodies and identities. The limitations in these areas stem from confidence in our understanding of them. The human, mechanical assemblage rooted in Taylorism is not new, as myths of automata were discovered across many different places worldwide. This approach is viewed as linear, step-by-step process in which students are expected to follow prescribed procedures to arrive at predetermined solutions. It fails to consider the subjects being taught.

The role of education in the regulation and control of bodies and identities is emphasized by the concept of biopedagogy, which is derived from Michel Foucault's work. The regulation of the child and its imagined limits is also limited by metaphors of power such as mechanical, capacity, and engineering. The relationship between humans and technology has evolved into an epistemological phenomenon in which humans understand both the material and non-material parts of their existence through engineering processes. The human, mechanical assemblage rooted in Taylorism is not new, as myths of automata were discovered across many different places worldwide. This approach is viewed as linear, step-by-step process in which students are expected to follow prescribed procedures to arrive at predetermined solutions. It fails to consider the subjects being taught.

Regimes of truths that shape the knowings of the self as mechanically operative beings are found throughout history and continue to the present. It is essential to recognize that the body, mind, and soul are all subject to ordering ways of thought and control, highlighting the potential for technology to manipulate human thoughts and emotions. Without regularly revisiting our tools and technologies, we risk merging with the engineered world and creating incontestable entities such as humanoids, artificial intelligence, and cybernetics.

Ultimately, the concept of social engineering and engineering the mechanical mind and soul raises important ethical and philosophical questions about the role of technology in shaping human bodies, minds, and souls. Therefore, it is crucial for educators to raise awareness about these issues and ensure that technology is used in ways that respect human dignity and autonomy. Additionally, the use of mechanical technologies, such as algorithms and analytics, for the control and manipulation of data should be considered in the broader context of the relationship between technology and society.

In summary, this dissertation explores the role of the engineer in advancing progress from multiple perspectives, including The Engineer as Hero, The Engineer as Myth, and the Engineer as Engineered. By applying the concept of dynamic nominalism, as defined by Hacking (1983), we can gain a better understanding of how the role of the engineer has evolved over time and continues to do so in response to societal changes and technological advancements. However, it is essential to avoid reducing the engineer to a singular icon and to acknowledge the complex and multifaceted nature of their role. The scientization of knowledge and the prevalence of scientific reasoning in contemporary society can limit our understanding and overshadow alternative forms of knowledge and values. Therefore, educators should expand their understanding, question their assumptions, and embrace discomfort as they explore their own beliefs and emotions. By doing so, they can open up possibilities for thinking about different subject matters with respect to histories, philosophies, anthropologies, and materials and how these ideas intersect with educational set pieces like STEM. Ultimately, this dissertation emphasizes the power of knowledge and the importance of critical thinking in shaping our understanding of the world around us.

Chapter 2: The Engineer as Hero

2.1 The Engineer as Hero

Monroe Boston Strause, nicknamed the Pie Engineer of the 1920s, transformed the pie-making industry with his scientific and technologically innovative approach. Despite his mechanical engineering background at Ohio State University, Strause delved into standardizing pie crusts, achieving uniformity and consistency. He invented a pie crust roller, comprising rollers and blades that cut and shaped dough into perfect circles. Consequently, bakers could produce vast quantities of identical crusts quickly and efficiently. Additionally, he developed the Pieoscope, a camera that determined a pie's filling depth and consistency, ensuring uniformity in baking (National Inventors Hall of Fame, 2006).

Strause's unconventional pie-making approach entailed using precise measurements and scientific principles, often utilizing equipment and techniques borrowed from the engineering industry. For example, he applied mathematical formulas to determine the optimal filling-to-crust ratio and measured crust thickness with calipers. His engineering technique enhanced industry standardization and efficiency, with many bakeries and pie-making factories still using his inventions and techniques.

Strause's industrial and in-home baking reformations unmistakably emerged from a scientized way of considering the process of making pies. Influenced by the economics of the home becoming the economics of business and industry, as evidenced by his pie-related patents, economic gains, and training regimentation, his system reflects how one might think about engineering in general. Strause's example substantiates the adoption of concepts of scientization, technologization, and the engineer as a hero and how one might consider these ideas. The application of scientific principles and methods to engineering has enabled engineers to create new epistemologies and truths grounded in scientific methods, which has contributed to the development of innovative technologies and the advancement of scientific knowledge in various fields. This phenomenon is referred to as the scientization and technologization of engineering. It has played a crucial role in shaping the profession and the broader society.

The media often portrays engineers as heroic figures who have the ability to save lives and make significant contributions to society. This representation of engineers as heroes has influenced the public's perception of the profession and contributed to the increasing popularity of engineering as a field of study. The Engineer as Hero perspective idealizes the positive impact of engineers on society and their ability to drive progress. This perspective has been demonstrated by historical figures such as Gribeauval, who was influential in the field of engineering and often praised for his innovative ideas that had a significant impact on military, economic, and management practices.

Gribeauval's standardization of production methods and use of interchangeable parts enabled the mass production of artillery pieces, increasing efficiency and output. In addition, his improvements to artillery manufacturing and design helped to modernize production by incorporating new forms of materials and technologies such as iron and steam power. Gribeauval's contributions exemplify the social influence of engineers and the significant impact they have on society.

In conclusion, the term engineerization serves as a helpful framework to understand the making of the engineer and engineering through science and technology influences. The technologization and scientization of engineering have enabled engineers to create new knowledge and technologies that have transformed various fields. Additionally, the media's portrayal of engineers as heroes has influenced the public's perception of the profession and contributed to its increasing popularity. Ultimately, the Engineer as Hero perspective idealizes the positive impact of engineers on society and highlights their essential role in driving progress.

2.2 Engineerization and the Heroic Engineer in Gribeauval's System

The term "engineerization[28]" provides a more specialized way to describe scientization as it relates to scientized and technologized entities. In the context of science, technology, and society assemblages, the term "engineerization" refers to the application and reapplication of scientization and technology, resulting in the creation of multiple layers of manufactured materials and methods that build upon themselves to form a system of engineering-based assemblages. The interdependent relationship between the engineer's actions and the application of engineering is effectively captured by the term "engineerization," as it can influence each other and affect the stability of the assemblage in various contexts (Feenberg, 2009; Callon, 1988). Despite the complexity of understanding the engineer, engineering, and engineerization through place and time, it is crucial to consider how the engineer exists in the present and

[28] Carotenuto (2022) defines "engineerization" as the pilot-scale testing of a chemical reaction to determine its practicality before production. This term, which is commonly used in the physical and chemical sciences, is a theoretical tool that encompasses scientific methodologies and technologies to produce more precise and efficient knowledge. By recognizing the interconnection of science, technology, and engineering through engineerization, one gains a more profound comprehension of the evolution of engineering artifacts from the past, such as Gribeauval's System, to modern-day advancements. This perspective also underscores the sociopolitical, economic, and educational influences that shape the trajectory of these artifacts.

provides the possibility of engineering existence and engineerization through a transformative place and time in history. In this regard, the 18th century, particularly the period and places that led up to the French Revolution, serve as a valuable lens for exploring these concepts.

Although various historical contexts shape the understanding of the engineer and engineering today, certain places bring together formative methods and norms that offer valuable insights into the ideas, discourses, and decisions that led to the concept of the engineer and engineering as a means of progress and salvation in present times. The engineer is recognized in sociopolitical discourses as a form of rational hero and driver of progressive endeavors through practicality, technological advancements, and deliverance of nation-states and societies (Nye, 2003). Such acclamation is noticeable in the general sense that one might consider in the present and the lines of truths that established engineering as holding certain powers rooted in science, technology, and society.

Traditionally, war has helped to create a variety of heroes whose cunning and brawn became legends. In war, heroes meet adversity and crisis with conviction and valor. They forge a pathway to victory and exceptionalism. They are revered, becoming archetypes for nations searching for a rallying identity. Routinely, as the hero's story becomes legend, the tales tend to mythologize or create extraordinary experiences, stories, and feats which set in place not only the historical actions and events but also the masking of truths that myths and time can obscure.[29]

[29] For example, consider the myths surrounding the first US President, George Washington. While most people are aware of Washington's role as a leader and hero, the legend about his honesty in cutting down a cherry tree (https://www.mountvernon.org/library/digitalhistory/digital-encyclopedia/article/cherry-tree-myth) appears to aim at portraying him as a person whose morals and virtues are consistent with his leadership and bravery on the battlefield.

The recollected aura surrounding the hero often reflects exemplars in character and discipline connected to the valor and courageousness of the hero. Here I will turn to the history surrounding the French engineer and hero of the Napoleonic Wars, Jean-Baptiste Vaquette de Gribeauval.

Gribeauval's heroic status is a product of his application of technologies, training, and managing battle contingents (Alder, 2010). Early advancements in material technologies, political structures, and economic markets helped to reimagine a society where areas of concern with the systems and material of war would merge with concerns of futures involving financial, cultural, and political standings. From these concerns, one might wonder about the hero in this context. To whom would society turn to make an exemplar in this new scientific and technologically focused world? Moreover, how does this hero exist today? Answering such questions provides neither a satisfactory nor complete answer, as such questions are entangled in social, political, and cultural understandings. However, to begin to think about the innovative hero whose methods and character, I propose looking at the 18th-century works of Gribeauval and his revolutionary engineering system.

Analyzing Gribeauval's System provides a way to consider methods and processes more complex than science and technology. The system not only encapsulates the materials and manpower to create a winning war assemblage but also includes new and enhanced systems of discipline, tools, measurements, standards, and ways of using science and technology rationally. This new form of regimentation, along with the patronage of the sovereignty and the influential members of the growing scientific community in and around France, redefined the nation's expectations in search of salvation through disciplined forms of scientific and technological pursuits. Likewise, in a society looking for stability and progress, such disciplinary forms offered new ways to work on the self as a means to advance a nation and export particular ideals. Such ideals would expand beyond the world of war machines into the material and non-material worlds of control related to industrialization (Higgins & Hallström, 2007), economic concerns (Alder, 2010), and pathologies to work on oneself (Rose, 1992).

Here it is essential to consider ties between a generic form of the present-day engineer and engineering in order to process power within the Gribeauval system. The engineer as s/he exists today is often portrayed as a practical and rational being with a higher-than-normal scientific aptitude and an objective approach to everyday problems (Florman, 1994). However, of course, this is merely a figurehead for the wide variety of types of engineers, engineering disciplines, and individual identities over a long period. While different ideals and modern observations might see the modern engineer as obstructionist or inflexible, my consideration of the engineer here seeps into the modern designer, architect, and draftsperson. While all are accountable to their own specializations, all work towards slightly different goals is rooted in engineering methodologies and standardizations. This portrayal of the engineer is not one of the absolutes, but an iconic representation of an engineer shaped by work, aptitude, systems of education, portrayals, and societal expectations.

By analyzing the Gribeauval system, one might envision engineering as a practical, efficient, and precise science that utilizes material and tool technologies to produce valuable and promising objects and systems of knowing. Furthermore, through this analysis, one might make connections to how the modern engineer exists as a practical and rational being working within an assortment of disciplinary matrices, including standardizations and organizations, best practices and methods, quantifications, hierarchies, mindsets, social responsibility, and interactions with the material and non-material worlds. Here, I offer a partial and simplified origin story of the modern engineer to begin to consider the engineer and engineering in the present and how engineerization or a stabilized form of science and technology could move through time and space, influencing and disciplining standards, methods, and bodies related to an amalgamation of science, technology, and engineering through related discourses and quantifications.

Next, I introduce the idea of technoscientific thought and the technological life, how the engineer and engineering are organized and assembled within society as a rational and practical person and practice, and how thoughts and methods are a product of such organizations and assemblages. In this analysis, I focus on the prevalence of engineering discourses and how certainties and pervasions of engineers, engineering, and education exist today. Engineering-related factors include societal influence, androcentricity, and materiality from numerous assemblages in which societal connections in and among engineering powers define, standardize, and mobilize particular practices. This mobility escapes from specific scientific disciplines and epistemologies (for example, genetic engineering in Jasanoff, 2019) into a vast array of systems, materials, standardizations, and people, all of which become swept up in engineering-like schemes.

Finally, the engineer and engineering in contemporary society are considered in relation to the institutions that discipline individuals' bodies, minds, and souls, such as schools, industries, political realms, and science-related associations and technologies. The phenomenon of disciplinary power in schools will be examined in depth in a later chapter. However, for the purposes of this chapter, it is beneficial to consider the impact of disciplinary power on an individual's potential to function as an engineer and how the notion of engineering as a stable concept across entities can foster a mindset of practicality and rationality at the expense of innovative approaches and discoveries, such as those found in quantum physics, which defy mechanical or normalized forms of physics.

This focus on the idea of the physical sciences in terms of their importance to a seemingly objective form of scientific sovereignty and governmental acknowledgment obscures that those committed to narrow definitions of rationality fail or refuse to observe. Such approaches present themselves in terms of attitudes of trust in technologies and the engineering function derived from experimental, measurement, and engineering practices and standards. The emphasis is on establishing trust in engineering practices and standards to the extent that they and their mobility become normalized through a society based on attitudes towards the rationality of science. This emphasis also has an indirect effect on society as new technologies of exposing and creating people through governing actions, institutions, and disciplinary technologies like pursuits in psychological science, sociology, and self-care, all of which take on a power of importance through new STE assemblages. Adopting such assemblages along with language and number discourses and the institution of such ideas provide a way of considering science, technology, engineering, and mathematics as it exists in the present form (especially in schools) as the concept of STEM and all its forms and brandings.

2.3 Gribeauval and the Evolution of Engineering: Military Success, Progress, and Systemization

Revolution and engineering go hand in hand (Alder, 1997). Engineering as a discipline is enmeshed with the future as an entity of concern that combines practices, disciplines, and raw materials to construct hopes of opportunity and salvation. Alder (1997) suggests that the French Revolution is a vast engineering project acting as a disciplinarian of the discipline itself. Revolution calls on societal demands of expectations of safety within the sociopolitical realm, salvation in both the physical means of warfare, and economic pursuits of wealth, efficiency, and freedom. In short, engineering and the engineer exist as both a concept and disciplinary technology essential to a society focused on comfort, salvation, and means toward a progressive life. The power of engineering moves not only through the war machine, as suggested here, but through the systems that rely on aspects of science, technology, and related truth regimes produced to provide solace and progress. Such systems are not only about generals, guns, and soldiers but also about designers, experts, and technicians. After all, not all revolutions are violent at first glance. Some revolutions forego the brawn to seize and control through technologies of disciplines and invocations of the mind. Such technologies have the potential to wield violence in altered and obscured ways. Moreover, the impact of these technologies extends beyond warfare and into other realms of society, including governance and industry.

The development of war engineering in 18th-century France played a significant role in shaping the discourse around progress, the sovereignty, and governance during the post-enlightenment era (Berkowitz & Dumez, 2016). These callings worked hand in hand as successes on the battlefield and progress in how the war was conducted created an evolution of warfare technology, defensive strategies, and security for the people of France (Alder, 1997). While several applications of science shaped significant advancements in technologies of war during this period, none is more celebrated than the Gribeauval System.

As a journeyman and researcher, Gribeauval gathered ideas from multiple ventures throughout Europe and, from them, developed an updated approach to military engineering and technologies. His restructurings of prior systems were unique in that he did consider not only the tools and material technologies of war but also the strategies and disciplines of soldiers, weapons makers, and designers. The workings of Gribeauval and his contribution to engineering weaponry before and during the French Revolution (Asdal et al.., 2007; DeLanda, 2008; Alder, 1997) are critical to understanding how modern engineering became a system of materiality and a way of materializing the body and soul. This historical frame helps provide insight into the systematization of science that we see in the military today and into a period when this systematization began to creep into other entities, such as industrialization and education (Alder, 1991; Alder, 2010). Alder (1997) argues that this creep can be noticed by tracings of modern engineering nomenclature rooted in early military discourses.

Additionally, while forms of engineering functions have existed for as long as recorded history, the work of Gribeauval encompasses much of how one thinks about the engineering approach in the present day. Under Gribeauval's influence, the progress of science based on engineering military successes expanded beyond boundaries and into new areas of technical consideration. This expansion was the result of fresh designs and methods which were differently considered and differently creative (Gillispie & Alder, 1998). This fact is not to say Gribeauval was the first to carry out any or all functions in this analysis. Many points amalgamate the engineering function under this single individual and his system. For instance, interchangeable parts, which became central to the efficiency and precision factors of the system, could be traced back to Carthaginian warships in the 3rd century BC (Polakowski, 2016). Pinpointing engineering technology is difficult as different technologies emerge in different periods and spaces, leaving some "first discoveries" victims of the "first published, recorded, and the like." Still, clear lines of influence are difficult to trace, even within this narrow framework.[30] Insisting anything was the first is not as important here as the way Gribeauval's methods created now familiar possibilities based on the concept of engineering and ways of creating new systems from new as well as existing technologies.

Gribeauval presents a system that hints at modern engineer and engineering methods. One can infer specific organizations of thought, methodologies, and mindsets through how the system produced material and non-material entities and how hierarchies of individuals were established. Demands of a wartime nation suggest adherence to modes of discipline, including regimentation, efficiency, and anticipation. Such qualities and subsets embody particular ideals of who the engineer is and how engineering looks. This embodiment exists in the present as a honed form of engineering that has become ever so specialized within its being but also acts as an organization of thinking for numerous other disciplines.

Within the scheme, Gribeauval's system expands beyond the material production of weapons and tools. The ways in which Gribeauval presented his system and described his training

[30] An example of this can be seen in the emergence of the Austrian and Gribeauval systems, which developed in distinct social, political, and cultural contexts and utilized the resources available to them (MacLennan, 2003).

regimen also provided an opportunity to consider the engineer and how the practical scientist of the time might exist today. Throughout Alder's work (1991, 1997, 2010), the engineer, as represented by an officer under the tutelage of Gribeauval or by Gribeauval himself, exists as a rational and objective conformist whose commitment to national ideology and exceptionalism is dependent upon both the government and society to establish order and efficiency as a means of progress. These purveyors of practical rationality provided hope, fairness, and the comfort of expertise in their establishment of rational ways of doing, knowing, and categorizing in order to imply a certain level of control over concerns of the time. The system is described in terms that relate to engineering in the modern era, including efficiency, precision, accuracy, quality control, meritocratic, intuitive usage, and instrumentalized (Alder, 1997; MacLennan, 2003; Weapons & Warfare, 2016). Many of these terms mark specific criteria of the modern engineer regarding methods, techniques, and ways of knowing.

2.4 Gribeauval's System: Enlightenment Rationality in Military Engineering

The prevailing faith in Enlightenment thought seemed to influence Gribeauval and his system through what Alder (1997) calls an "absolutist rationality." This term implies an understanding of a phenomenon based on a narrow set of explanations founded in scientific reasoning. This form of rationality impacted the design and production of equipment and the long and short-term training of individual war tactics and stability. Early systems focused on rigid regimentation, limiting balance, and commitments to realms of possibilities of training and design. The system helped supporters achieve all these tasks in a way that displayed differing iterations of loyalty to the system, the engineer, and the sovereign himself. Comprehensive programs which deviated from the system required a persuasive argument to the sovereign and the centralized powers of the French Government. Before Gribeauval's system, credibility was often rooted in religious tradition, historical arguments, philosophical reasonings, or how to complement the stakeholders. It was unlikely that individual designers held enough power to effect change. Nevertheless, it was Gribeauval who was able to integrate enlightenment-era convictions into 18th-century France, where shifting concepts about what constituted evidence and knowledge production opened the realm of possibilities and usefulness by applying science systematically and helpfully. For the sake of the French military and France as a nation, a new system was needed. The Gribeauval system, while not a wholly new concept, incorporated elements from previous designs, such as Valliere's system, which had its own unique design advancements. Despite this, Gribeauval was able to convince his superiors that his "advanced" system offered differences in how wars could be fought, and workers could be trained, leading to greater effectiveness. The system's rise occurred during a time when rationality was highly valued, and there was a willingness to adopt particular expertise and standard practices related to warfare, material alteration, and worker training.

The promise of revolutionizing material production and impacting the war machine made the Gribeauval System attractive to French elites and noblemen. Its influence can be seen in the military's "Republic of Letters," a system of communication that circulated discourses on tactics and technologies among military authors and scholars. This exchange of ideas and ideals regarding social, political, and military issues reflected the Enlightenment thinking of the time. It was recorded in public records across Western Europe and the Americas. Gribeauval's system gained political, cultural, and social influence through democratic ideas central to the ideals of this group. The organization and success of the system warranted replication in many different disciplines in many different places based on observations of discourses, interactions between materials and workers, and hierarchical structures (Alder, 1997).

This forum opened military-centered public discussions hitched to areas of science, customs, morals, and politics without governmental agencies shaping ideas and agendas, laying the groundwork for criticism and competition in how the military should be enacted. "It also gave scope for greater intellectual cross-fertilization: Gribeauval's system, with its readiness to abandon tradition and privilege in favour of utility . . . showed the direct influence of the philosophes' critique of French society (MacLennan, 2003, p. 15)." According to Alder (1997), French Artillery resulted from "Enlightenment Engineering" - a process that sought to standardize and formalize engineering as a discipline. This approach had a profound impact not only on military strategy and governance but also on political, economic, and educational institutions. As new systems replaced old ones across Europe, the principles of rationality and practicality became widely adopted.[31]

Gribeauval's system put forth ways to engineer a complex system of military might, machines, and men utilizing ideals grounded in rational scientific thought and a commitment to practical solutions over all else. He represents the rational and practical problem solver whose mindset centers on community, expediency, and objectivity. He created and improved materials, methods, and ways of knowing related to practical science through "engineering know-how," the evolution of technologies, and practical science itself. His attention to particular tenants of engineering, including discipline, efficiency, and precision, have been influential in the

[31] These replacements relied less on pre-enlightenment truths based on religious justification and more on the rationality of science and the practicality of particular systemizations based on scientific truths and methods.

continuation of ordering in military pursuits and in the advancement of industry, justice reformations, and education. Such tenants would become an influential part of the scientization and technologization of political, bureaucratic, economic, and educational entities in the early 20th century.

2.5 Standardization and its Impact on Engineering, Science, and Society

Gribeauval's strive for precision and efficiency helped create subsystems of organizations based on strict production principles, uniformity, and evaluation. His efficiency and precision, as they relate to standardization, were hailed as a significant advancement to the progress of France's military power. Such progress was noticed in the cost-effectiveness of uniform parts and training regimens. The mobility of both materials and ideas opened opportunities for more output and precision in workplaces across France. Standardization was vital to the system as it provided efficiency by utilizing new production levels, reducing product weight, and reducing production costs and time. Standardization also simplified the postproduction service of products expediting the processes of repairs, modifications, and replacing parts.

The emphasis on standards and material components allows for crucial decisions regarding standardization, such as the development of the widely recognized Universal Standards. Precision and standards in mechanical applied science had been the focus of a program of unifying standards in and around Gribeauval's time, with the legends of Galileo and Newton as the guide (Ferguson, 1994). Gribeauval's system facilitated the development of consistency and precision as part of the engineering process. Engineers produced standardized features based on measurements and materials to work within the standards system. Every aspect had to be able to fit within any other accompanying part. With this system came precise designs, specifications, drawings, and tools. This design scheme required quality control, assessment, and retooling to limit any variation. Engineers created technologies explicitly to advance other technologies creating structures and systems removed from the origins of phenomena and solutions towards newer elucidations and technologies.

Each time standardization is iterated, the corresponding scientific understanding of the original phenomenon becomes more entrenched as the resulting technologies expand into new practical applications. As engineering advances create new scientific and technological questions, the push for practical solutions and the manipulation of technology makes it challenging to entertain alternative explanations or truths about the original phenomenon. As technology continues to progress within a limited, rational-based conception of how learning, reasoning, and intelligence are formed, as well as how inclusion and exclusion are affected, it becomes increasingly difficult to imagine new possibilities for advancement beyond the confines of this narrow reasoning, which can limit potential solutions and create new problems (Winner, 2012). The use of engineering and design concepts rooted in scientific rationality, mechanical logistics, and practical approaches fosters a particular mindset and biases toward those who embody the ideal engineer in terms of intelligence, values, and characteristics. This results in a narrowing of possibilities in how we interact with nature and advance towards creating "artificial" systems and technologies that are modeled after human nature, such as artificial intelligence, cybernetics, and algorithms. The notion has dual implications - it is helpful in a pragmatic context, such as purchasing bolts, washers, and nuts at a hardware store. However, it is also restrictive because it entails a teleological approach to assembling materials, where decisions made in the past (in this case, the choice of bolts, washers, and nuts) dictate the current method.

Kuhn's (1962) idea of paradigm comes to mind in this scenario. Just as revolutions of outliers in normal science collect to break paradigmatic boundaries, so too does iterations of standardization. However, to compare standardization as relative to "normal" science [32] that needs to be revised. In this system, new epistemologies build upon themselves and move away from the original phenomenon of concern, becoming increasingly distant from the new epistemologies. This way of knowledge creation opposes the basics of Kuhn's normal science in that, in his description, normal science stays close to and revisits the originating phenomenon. At the same time, standardization bores through paradigmatic boundaries creating not new ways of discovering science but new ways of utilizing science. Because of this, engineering generates systems of standards which, in its drive to become a practical tool in the sense of usefulness to society, transcend the science world and seep into the lives of the non-scientist.

According to Gooday (1990), the emphasis on measurement, which is foundationally tied to physics, has extended to other fields such as engineering, chemistry, and physiology. This extension of scientific practices to other disciplines has led to the normalization of seepage with the authority of science and the trust vested in engineers. As the principles of physics and engineering were applied to other fields, new standards and methods of measurement were required in areas like biology, physiology, and chemistry. Through networks of discourses and

[32] In his book The Structure of Scientific Revolutions, Thomas Kuhn introduced the term "normal science" to describe the established and systematic work of scientists in the present. This includes methods such as observation, theorizing, inference, experimentation, and others within a well-defined and accepted intellectual framework known as a paradigm.

social actions, determinant factors related to measurements, standards, and causality form transformative rules of inclusion and exclusion in creating knowledge, materials, and individuals based on ethico-political interests in accountability and responsibility (Zheng, 2021; Barad, 2003). Societal and political trusts in such cyclical binary patterns [33]of an organization that relies on an a posteriori which influences the perceived necessity of action with a confidence in the solution no matter the unforeseen or ignored effects (Zheng, 2021)[34] . However, the normalization of such seepage was not always immediate. The assumptions of commonsense and convenience of standardization noticeable in present-day existences were not without opposition in the time of the Gribeauval system.

The development of new technological disciplines in the nation's production control was heavily influenced by the organization and regulation of standardization. However, the power and standardization associated with modern management standards did not come easily, as social, cultural, and political resistance existed. As a result, new methods of categorizing and disciplining workers emerged, ranging from hostile workers to low-skilled workers, to high-skilled trainers and designers. This categorization system introduced a novel way of assessing workers based on technical ability instead of traditional craftsmanship (Alder, 2010). Incorporated into this are used within a system of peer review, assessments of competency, and

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[33] I argue that cyclical binary patterns as similar to "If-Then-Not" statements where criteria obscured within algorithms provide definitive answers while possessing the façade of objectivity.

[34] Zheng (2021) explains this concept as "how A is differentially made with and through C(s) to account for B while A, B, and C (s) can only 'be' and 'do' in relation to each other. . . (by putting) 'world crisis' (as B) and its identified incentives (as A) through systems analysis of change (Cs) to account for the effects of the intra-action between C(s) and A/B." In the next chapter, I incorporate the term apperception as a way to consider knowings through endpoints and patterns which assume a determinant causality. Apperception produces and upholds knowledge not through understanding a priori phenomenon but of "reverse engineering" systems to reform them for alternative use.

ideas of efficiency and precision. As a result, salvation through engineering in war became reliant on these technical "types" of individuals and the standardization of the worker in a system.

2.6 The Impact of Gribeauval's System on Artisans and Craftsmen in France

The uptake of Gribeauval's system exasperated the demise of the artesian or craftsman worker whose standards and evaluations came not from a book or state-backed entourage but from localized culture, traditional training, and domestic materials. Some resisted change. Others joined as low-skill workers who joined other non-artisans to follow the rules and methods of Gribeauval and his corps of engineers (Alder, 2010). Unlike earlier traditional crafting of weaponry, workers in the Gribeauval system did not oversee production from beginning to end. However, they became trained in particular manufacturing modules that compartmentalized tasks removing traditional means and identities of products as they relate to the craftsman. Expertise was centralized and distributed throughout France into production shops and within hierarchies of workers within those shops.

Gribeauval's system relied on preselected materials, shapes, sizes, fittings, assemblies, and other elements that exhibited a high degree of technical uniformity. However, Gribeauval did not oversee these tasks personally; instead, he established a group of skilled workers who were trained in his system to disseminate the technology throughout France. These skilled workers not only mastered the Gribeauval system but also learned how to transfer it to production facilities that were critical to France's future due to their adherence to the system and production capabilities. The system emphasized conformity to the rules of production, precision, and efficiency through standardization, organization, and discipline to implement new directives. Additionally, the skilled workers excelled in repurposing older designs to improve upon newer ones, melting and reforming materials, and replacing obsolete technologies with newer ones.

With the formation of this system and the authority bestowed upon him, Gribeauval came to control the means of production and individuals whose identities had been sorted based on their connections to technologies of production. Artisans and craftsmen were marginalized and made unserviceable all over France because of the switch to mass manufacturing operations focused on mechanics and consistency of outputs instigated by the commitment to standardization methods. Madhavan (2015) noted that systems of longevity and loyalty in promotions were replaced by a technological meritocracy, which was codified by Gribeauval through a merit-based training system for his labor force. This change in promotion policies also brought about new hierarchies that differentiated workers based on their physical and mental abilities. As a result, it became necessary to engineerize the workers' abilities to make them visible and better suited for their respective tasks.

Along with this change, technological meritocracy would come with new ways of measuring the measurers and caste the casters. With such a design for worker levels, new ways of measuring bodies, minds, and loyalty would become necessary. Materials and machines would be central to the system and would become actants to the order by providing interactions with workers through body, mind, attitude, organization, and allegiance. The system called for discipline. Designers created the technologies of discipline, while workers were categorized based on technical prowess and loyalty to the system, the sovereign, and the ideals of progress.

MacLennan (2015) argued that the Gribeauval system had a profound impact on the social and political relations within the artillery service, as well as the prevailing conception of war. Specifically, it disrupted the existing order by overturning the conventional definition of merit, which was predominantly based on seniority, and instead prioritized technical expertise.

In this transformation, loyalty was not about the years of experience and what could be learned but the ability to unlearn experiences and relearn production based on a new system of engineering. The layering of the engineering of products and production would be turned on the engineering of bodies, minds, and souls as an outcome of the system design.
Judgments, feelings, and passions became subject to the whims of machines, mechanics, tools, and templates. Engineering designs aimed at the union of the materials, bodies, and minds would become a kind of subjectivity in which reliance on engineerization would become normalized as a way of rule-following, disciplining, and controlling problems, great and small.

Standards became technologies of organization and discipline. Experiments, measurements, numbers, charts, graphs, evidences, and the like all became a way of organization, organizing, and sorting. They became ways of design, of designing, and of being designed. They become ways of existing as an engineer, of engineering, and of being engineered. As the increased usage of measurements and standards became more and more critical to scientific discovery, economic interests, and progressive convictions, the ability to define and control measures and standards became an imperative pursuit toward progress. (Weber, 2004) points to the effects of standardization and the consequences on human subjects as a point where the hierarchy of those in science began to crystallize into the thinkers and the doers of science or the scientists and the technician.

In a way similar to Latour & Woolgar's (2013) study of the work of scientists in "Laboratory Life," one might see an engineering take on the utilization of method, design, and technology producing blueprints and ballistics information which encompasses the work of many and transforms those documents into immutable mobiles, or documents which hold certain powers or advantages based on their production and ability to move place to place. Those more skilled and faithful to the system would create the standards and parameters of the system. In contrast, those less skilled would enter into modularized production, working at specialized tasks as contributors to the system, the sovereign, the society, and the nation itself (Morales-Doyle & Booker, 2021). This split creates a simple hierarchy of skilled and unskilled, which over time, has the potential of gaining more and more levels based on several different factors[35]. Here the work of the unskilled is dismissed in favor of the product, the means of production, and the system itself, all of which are credited to Gribeauval, the "brilliance" of the sovereign, and progressive-focused loyalists.

Disciplinary technologies took many forms in Gribeauval's system. Immutable Mobiles[36] are not just limited to documents. They also include technologies such as science discourses, scientific

[35] The production of more skilled vs. less skilled workers as binary categories as they are graded through the framework of assessment and surveillance, including self-disciplining, forming particular subjectivities, but less concerned about the subjectivity than the outputs (standardized results, transmission of codified knowledge, language, skills).

[36] Morales-Doyle and Booker (2021) use critical race theory and disability studies to analyze how tracking in science education reinforces systemic inequalities by sorting students based on perceived abilities and limiting access to opportunities for growth.

and engineering drawings, methods of production of such drawings, scientific modeling, epistemologies, measuring methods, and training. In accordance with Zheng's (2021) idea that scientific and intellectual traditions function as both objects and models of knowledge that establish epistemic values, this statement aligns well. This notion is supported by the work of Rheinberger (2010) and Daston & Galison (2021). The Gribeauval system is an example of a historical system of artillery design and production that, like those referenced by Daston (1991), provides a framework for organizing ideas, evidence, and reasoning that parallels the uniformity and interchangeability of the physical objects themselves. Uniform production depended upon physical tools, epistemologies, and models whose utilization and comprehension would be critical to the function of the system. Madhavan (2015) refers to the work of Gribeauval's system compared to the creation of craftsmen as "functional binding," in which parts and workers of the system interface in a way that creates the most efficient outcomes. They are strategic in design, with each module or section in charge of one output type.[37] Machines and minds were preset to produce exemplary and uniform pieces to advance the nation's military power. Technologies came in the form of early blueprints, calipers, gauges, and jigs, all of which played a part in the precision production and uniformity of the end product. The artisans and craftsmen who embodied the means and production based on entities like localized and cultural thought, tradition, and ritual became sectioned into scientific means. Gribeauval would expand his engineering influence by using immutable mobiles (Latour, 1996), like some of the technologies listed above, across space and time, along with the training and disciplining of "skilled" workers.

[37] This approach became significant for industrialization in the realm of assembly lines and is still evident today in the way DIY enthusiasts buy pre-assembled units for repairing cars and home electronics. Modules, considered a more sophisticated material assemblage denoting advanced engineering, were initially used for the parts of weaponry but could now refer to components such as a computer's hard drive or a car's water pump - units that can be plugged into a more extensive system.

2.7 Gribeauval's System: Standardization and Meritocracy

Gribeauval's system trained experts, not artisans. Experts focused on particular parts and methods within production instead of the craftsman whose work was holistic and whose production saw the making of the product from beginning to end. This change would not be taken in stride by the craftsmen and artisans whose livelihood and culture were defined by their work and routines. This vision of training experts was radical as it upset social and political service structure norms, forming a more efficient and standardized "merit" system based on what was considered technological competence and a "peer review" process to assure a certain level of quality. This "meritocratic" and "peer-reviewed" approach proved a commitment to the system as it ascertained a transparent exercise of power and obligation to the methods and system of Gribeauval and his influence on the sovereign, the noblemen of France, and a trusting and progressive focused society.

Competition assured the disciplining outcomes of close adherence to the rules, methods, and Gribeauval's system. The modification of products and changes in production were tolerated only through levels of scrutiny of those deemed experts in the rules and regulations of the system. Quality control [38] would become important in the system as well, as metrics of war began to change. Where once numbers related to movements, protective indicators, and kill numbers acted as sole indicators of success, new ways of quantification, standardization, and assessment would describe successes and failures before weapons even left the shops (Madhavan, 2015). New numbers, joined by more detailed and specific measurements, graphs, and data under the Gribeauval system, created new ways of seeing success before a cannon was mobilized or a shot

[38] Engineering of segregated and colonial schooling as means of quality control within eugenic, euthenics, and Americanization campaigns.

was fired. According to Alder (1997), such uniformity acted as a way to erase the influence of old regimes by rendering complete systems obsolete. Alder compares Gribeauval's use of uniformity as similar to the adoption of the metric system throughout most of the world as a "deliberately crafted" scheme to break the political economies of traditional regimes and dated systems. The need for uniform testing created yet another layer of design that relied on the accuracy of measurement and socio-political influence, employing advanced considerations of expertise and evidence.

With the need to structure the top of the hierarchy within the system, individuals would require specific training and knowledge to uphold the integrity of and confidence in the system. All this is in an attempt to normalize the engineerization[39] of the system. Such normalizations have the potential to obscure particular problematics making the practical application of science impractical for some. Here, the lens through which science is applied bears some consideration. For instance, Barry et al. (2013) argue that the study of physics and other "exact" sciences is through two particular shifts in sociopolitical thinking. The first shift deals with the change in the natural sciences movement away from histories of theory and towards more practical means involving histories of experiments, quantifications, and practices. This concept also relates to how science-adjacent groups glorify science by creating narratives of advancement through narrowly defined humanities and uncritical forms of political success. Looking at this through an engineering lens, one might observe societal influences, androcentric desires, and materiality from numerous assemblages in which societal connections in and among science. Technology and engineering powers legitimize and define, standardize, and mobilize particular practices.

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[39] Here the term engineerization provides a way to think about the standardization of science itself or the confidence to normalize a natural phenomenon in terms of occurrences, related quantifications, and empirical perspective.

The second of Barry et al. (2013) critical factors involve the idea of the physical sciences in terms of their importance to a seemingly objective form of government extension. Such histories present themselves in terms of attitudes of trust in technologies and the engineering function derived from the first point above ("experimental, measurement and engineering practices and standards"). The focus is on establishing trust in engineering practices and standards to the extent that they and their mobility become normalized. These methods, techniques, and standards get reapplied to various scientific resemblances and become a part of governing conduct. More specifically, engineering technologies like standards, quantifications, measurement, and the like, used to understand better and objectify nature, are analogous to the disciplinary technologies or techniques of the self that Foucault (1966) introduces (in Cisney, 2016).

2.8 The Gribeauval System and the Complex Assemblage of Science, Technology, Engineering, and Sociopolitical Interests

The question of nature as something different in modernity arises. One is often taught that science is valuable because it is objective. Science is not about planned outcomes but about understanding what exists. Engineering involves strategic planning to achieve specific outcomes. It relies on scientific principles as a basis for prediction but is influenced by subjective factors that may be rooted in social, cultural, or political contexts. Despite this, objectivity remains a crucial principle for engineers, particularly when it comes to preventing or analyzing failures. Science and engineering work together symbiotically to identify inconsistencies and areas of improvement. Unlike the blueprint for an engineering marvel like the Brooklyn Bridge, scientific knowledge is constantly evolving, with hypotheses leading research in various directions. This flexibility permeates a range of disciplines and epistemologies, extending beyond traditional scientific realms, such as discussed in Jasanoff (2019), and affecting systems, materials, standardizations, and individuals who engage in engineering-like pursuits. The diverse range of engineering and design forms may have arisen from the popularity of systems such as the Gribeauval system and those that followed.

The engineer's objective service to the people offers the hope of a fair-minded and rational individual with the ability to solve practical problems to protect and enhance life. Because the engineer's function not only serves people in the present but also is a prophetic entity in which futures lie, systems are sometimes decided upon, implemented, or even proposed based on societal anxieties, loathings, and apprehensions. Seeing the future as a space of opportunity and trepidation supports how applied science and technologies are celebrated and valued. In this way, any association with engineering can claim prophetic powers, salvation, and a maintained "good life" (Adams et al.., 2009, p. 44). This description of the even-keeled engineer was even used to describe Gribeauval himself. His is noticed in Hennebert's (1896) description of Gribeauval as "an enlightened, man without passion, familiar with the details and creditworthy to go to the good solution . . . (p. 36)." Gribeauval's system put forth the idea of a form of science for the people and the nation. This practical use of science helped build support coalitions around tangible engineering and technological productions. In contrast, though foundational in the system, the undergirding structures of science were less noticeable (Alder, 2010).
Gribeauval developed a system that was shaped by Enlightenment scientists and put into action for the support of the state and a secure future rather than for the advancement of science. As Madhavan (2015) explains, Gribeauval's system was developed to serve the practical and

pressing need of winning battles. The system was designed to serve, protect, and kill. Gribeauval's solutions had to work, and failure was not an option.

According to Alder (1996), natural philosophers like Galileo and Newton viewed the study of ballistics as a "mathematical gymnasium" with little practical application in the complexities of warfare. Instead, mathematics was seen as a way to quantify how changes in certain measurable parameters affected other relevant parameters. The study of ballistics moved military engineers from being mere theorists to practitioners. This present-day form of engineering is rooted in applied science, which is the custom of using scientific principles to solve practical problems.

It is crucial to acknowledge Newton's contribution to modern engineering. According to Barry et al. (2013), Newton's approaches of experimentation, quantification, and standardization, along with socio-political interests, transformed the physical sciences from a foundational discipline to one element of a complex set of technological assemblages. These technological assemblages were disseminated through various means, such as industry, science education, and governmental interests. Gribeauval's system was intended to serve the practical needs of the state and secure its future rather than advance scientific knowledge. Its influence extended beyond the military and into many aspects of everyday life, both material and non-material. Thus, Newton's foundational approaches, combined with powerful socio-political interests, transformed the physical sciences into one element of a complex set of technological assemblages with far-reaching effects on society.

The Gribeauval System was a complex assemblage of men, materials, and sociopolitical influences, which worked together to create truth regimes, standardizations, quantifications, and apparatuses through the power of science, technology, engineering, and sociopolitical concerns and desires (Barry et al.., 2013). Lampland & Star (2009) note that standardization has become a central feature of social and cultural life in modernity, with its purpose being to streamline procedures, regulate behaviors, demand specific results, or prevent harm. In addition, the movements towards unification across nations in the 18th century became central to the influence of governments, with countries like Germany and Britain setting up Standards and Precision Laboratories to compete for economic and political prominence (Barry et al.., 2013).

As these assemblages evolved, certain elements were introduced, tested, and embedded into a way of thinking about the intersection of science, technology, engineering, and sociopolitical thought. Furthermore, discourses based on standardizations became political battles needing mediation when set on an international stage. Just as in the Enlightenment era, science quelled its disputes, and the concept of standardization became tied to a progressive agenda grounded in physics and engineering standards (Barry et al.., 2013). Through this lens, scientific thought is not just a product of science itself but as an assemblage of science's truths and rationalities, the precision and efficiency of technology, and the practicalities and assurances of engineering and connections to societal norms.

The 'second industrial revolution' that emerged after World War I relied heavily on standardized components, drawing conventions, and products in precision engineering to mass-produce items such as cars, household appliances, and agricultural machinery, which resulted in the rise of engineers as an influential and esteemed profession in industry. This development triggered the emergence of an international standardization movement in the late 19th century, which intertwined with similar movements around industrial rationalization and simplified practice aimed at reducing unnecessary variety in manufacturing (Higgins, 2005; Shenhav, 2002). Standardization offices and agencies emerged as a result. In addition, new methods of measuring and categorizing products resulted in the analysis of a wide range of goods, from screws to condoms, from rail tracks to pajamas, and from boilers to swimming pools. Quality Control standards reflecting Gribeauval's work reappeared in subsequent wars (such as World War II) and consumer goods, with these standards have become universal to this day (Higgins & Hallström, 2005).

2.9 Technoscience, Gribeauval's System, and the Engineer's Role in Society

The Gribeauval System and the potential for ties to artifacts of present-day discourses and methodologies offer a way to make the engineer and the process of engineering strange in its uptake of the localized and self-disciplining of bodies. Social acceptance and political influence offer a space by which rational thought and dominion over what was considered "natural" provides an opportunity to begin understanding how the engineer became the embodied and organized way to seek and assemble truths once disjointed by science and natural philosophy.

The military successes of Gribeauval’s system provided a sense of hope for the progress of societies throughout France, utilizing the process of organizing science into a useful and domineering form. Minds, muscle, and discipline organized by and for the common good seem to offer a promising future not only in war but in other ventures. The reapplication of

Gribeauval's system would have far-reaching effects beyond its original military utility, penetrating areas such as industry, education, medicine, and social organization. It is essential to recognize that the boundaries between science and society, and between the technical and the social, have never been set in stone. In fact, they are currently being reconfigured in ways that challenge our previous assumptions. As research continues to push the boundaries between science, technology, society, nature, culture, subjects, and objects, it becomes increasingly difficult to differentiate between them. Latour (1989) contends that the integration of science, technology, and engineering with society is so seamless that it is impossible to separate them from the morals and values of persuasive members of society. He terms this integration technoscience, which serves to challenge the traditional boundaries of "science," "society," and "values."

Under Latour’s (1989) definition, technoscience further complicates the STE assemblage, adding a societal variance of power producing new tethers to the original assemblage into the mix. This vision opens technoscience to a whole litany of sense-making influences and the establishment of truth regimes based on the adoption of this ideology. Such influences might include decisions based on non-traditional scientific thought, such as societal trusts, the salvation of the abject, discipline, and good citizenship. Definitions might include new conceptions of materiality, capacities of measurements, and the organization of the "rational" mind. Moreover, the technoscientific assemblage, influenced by Enlightenment thought and scientific rationality, has the potential to become normalized and romanticized, providing a sense of purpose and meaning for nations with progressive aspirations, exceptionalist delusions, and arrogant forms of salvation. Engineering becomes grounded in one particular science and spreads into other disciplines, while the engineer is viewed as embodying progress, salvation, and social responsibility. These perspectives draw on similar tropes as those associated with the Gribeauval System. By examining the ideas, discourses, and decisions of that period, we can understand the creation of the modern engineer and their connection to society, offering insights that connect to present-day truths and knowledge.

As Gribeauval's system gained favor with the sovereign, the capability for the system to be expanded despite the pushback of artisans and the reorganization of production occurred. The power of the artisans seemed to be overshadowed not only by the state but by influential thinkers and the promise of salvation and progress. Societal ambitions, trust in expertise, and the want for stability opened opportunities for individuals to become engulfed in a technoscientific existence. The Gribeauval System satisfied those needs. The influence of science and technology and their application offered the potentiality of a demystification of all, including the barriers of the material and non-material, the living and the non-living, and truths and non-truths. This mindset made for a level of progress that offered dominion over the "unscientific," the "irrational," and the "wretched." [40]

As scientific and technological advancements were applied and truths were assembled, engineering became a practical means of control that was visible and disciplinary. This power shift was particularly evident as the STE assemblage was used in service of the sovereign. As the focus turned towards control rather than mere understanding, Alder (2010) highlights the disconnection between nature and the engineering mindset, using the term design to refer to the

[40] This also set the stage for the potential of power influences such as Androcentrism, Patriarchalism, Dominionism, and other control methods.

application of engineering principles to a non-natural world. Alder notes that engineering differs from science in that it is focused on progressing human influence over the way something exists, with goals and outcomes formed through negotiated exemplars. When considering the role of engineers in society, Alder (2010) notes that it is a contentious art, and that designing an artifact is, in some sense, a political act, emphasizing the social and political nature of engineering. As he writes, "They (questions) remind us that engineering is a contentious art, that engineering is always social engineering, and that designing an artifact is in some sense a political act" (p. 12).

2.10 The Gribeauval System and the Ordering of Engineering

As an apparatus of the state, the modern engineer offers rational solutions to present and future objects and situations of concern. These concerns are born of different times and modes of thought but often form from fears and shortcomings. As such, they become vital to societal appeasement and discipline by shifting toward scientific solutions for the subjugated citizens. Higgins & Hallström (2007) argue that shifts in rational thought propagated by the government provide the possibility of salvation through standardization of action, knowledge, and methods forming a situation where these entities are retained and protected utilizing governmental technologies. As governmental technologies intertwine with other forms of salvation and preservation, economic entities also entangle themselves in the web. As standards-related ideas progressed, they began to form control systems that helped erase the boundary from the material world and onto human bodies. Higgins & Hallström (2007) go on to state that the discipline of management "sprung from the same engineering loins (as standardization) at roughly the same time. . . In the recent period, both disciplines have converged in management standards, the most important form of standardization as a technology of government (p. 688)." The application of engineering methods became systematized and employed in various places, giving the pretense of being scientific.

An analysis of Gribeauval's guns as an actor in the network of the production of the engineer and methods of engineering provides a way to consider how the engineer exists in the present. As mentioned, the Gribeauval System integrated intricate standardizations of products, materials, and men (Madhavan, 2015; Alder, 1997; MacLennan, 2003). Design, production, and quality control in the Gribeauval system would become the foundation of engineering today. There is no implication that these actions did not occur prior to the Gribeauval system. However, it is here where such means of production are systematized under particular methods and standards. Gribeauval standardized gun calibers, cannon calibers, gun carriages, limbers, ammunition chests, and tools (Rothenberg, 1980). He also maintained all aspects of production, including labor. Interchangeability of materials and men would become essential to manufacturing and production in areas where different interested factions considered economic security and physical protection. Measurements and specifications set parameters for materials and men alike. Calipers and scales would not only create or dismiss the exemplary part of the cannon but also create or dismiss the exemplary worker, technician, and workshop across the nation of France. Such a system of proficiency and control becomes technologies of discipline and surveillance similar to those seen in military situations, economics, and education. Nevertheless, instead of calipers acting upon the materials and individuals, we often see proof of standardization through properly made beds, credit scores, and the standardized test.

The Gribeauval System provides a way to think about the ordering of engineering in both material and non-material ways (thoughts, motivations, values) (Asdal et al., 2007; DeLanda, 2008; Alder, 1997). Latour's (1986) concept of the technoscientific offers a way of embedding science, technology, and all their baggage of ideas and materials into the social and individual consciousness as if their existence is inborn or exists as such. Latour's (1986) invitation to consider the complexity of science intermingling with society becomes more evident as the actor-network theory (ANT) (as introduced in the first chapter) comes into play. Callon (1984) and Latour (1986) offer similar ideas of ANT. Essential here is the removal of a person or persons from the privileged position in order to analyze the impact of the creation of scientific knowledge and the interactions of science and society. By applying this theory, one could better understand the fluidity of science under the influence of natural states of being, societal pressures and desires, and political influences (Callon, 1984). Examples include the Gribeauval's guns and the tools[41] of inspection, their impact on engineering methods, and how they became the basis for the exemplary engineer.

Alder's (2010) argument suggests that technical tools such as gauges gain agency in the complex interactions of artisans and controllers of production. According to Alder, gauges and tolerances belong to an asymmetrical form of objectivity, which appears more stringent the lower the hierarchy. For the artisanal producer, gauges define the limits within which they must work, while for the controller, they define the zone within which they are not likely to be called to account. For the manager, they serve as guides about which they can exercise judgment. However, policing work with objective measures only substitutes impersonal for personal

[41] Gribeauval's system would replace the Vallière system based on means one might recognize as modern engineering principles of efficiency, precision, and intuitive usage.

relations. "Objectivity" looks different from different places in the social hierarchy-and so do objects.

This concept suggests that materials gain a level of agency in the system and non-human actors can affect bodies, methods, livelihoods, and loyalties. It is not only the products produced but also the technologies that make, assess, and standardize those objects, including gauges, fixtures, cutters, and automatic machinery. The politics of material goods (Berkowitz & Dumez, 2016) negotiate measurements, guide bodies, and standardize parts. They negotiate in the form of "Go and No-Go Gauges" to assure quality, as in the form of a cutting guide or jig moving the hands around objects and standardize as in the form of removal of craftsmanship and interpretation. According to Zheng (2021), "performativity is no longer limited to speech but also referring to the discursive-material arrangement of time–space that constitutes the subject by enabling words, images, numbers, and other artifacts to do things upon bodies."

The influence of technoscience shapes material objects and, later, categorizes and shapes bodies through the powers of preventive measures. Disciplinary technologies discipline the self and create parameters for materials, the material body, and the non-material body of the soul. These forms of tolerance or limits on what is acceptable and unacceptable grow from these human-material interactions. At some point, human interaction would be eliminated by automatic machinery, and engineering selects qualities for an automaton where the possibility exists. Alder (1998) extends this concept further by stating, "And as for more special-purpose machines with the fixtures permanently installed (as in Fordism), they can then be seen as the final step in the logic of mechanizing, and hence 'objectifying,' the standards of production" (p.52). As Localized production replaced standardized mass production, Artisans would need to relearn how to see and render objects in the Gribeauval way. They would reconsider forms of their craft and what remains in their traditions that would match up to the new "proper product." Their bodies would learn to move differently. Their hands would be guided not by experience but by new standardizing and disciplinary technologies like jigs and templates. Their devotion would be in their commitment to the sovereign, society, and the technical life (Alder, 2010). Disciplines like technical drawing and mathematics became gatekeepers to certain statuses, levels of expertise, and rankings of people and institutions within the system.[42]

Technologies of discipline became intermediaries between bodies and materials, between engineered and crafted, and between standardized and the organic. Berkowitz & Dumez (2016) consider the power of these tools in the realm of non-human actors in systems that acquire both agency and power in the realm of science in the mode of Latour (1989) and Callon (1984). In this case, power is deployed utilizing tools that measure quality based on precision and efficiency rather than craftsmanship and tacit quality. These tools applied to the products of the Artesian were a way to rethink production and control craftsmanship into non-existence. The body formed and deformed by the old methods of production was being reformed and disciplined in conjunction with new tools to engineer uniform constructions. The assemblages of body and technologies are noticeable in numerous parts of the "technical life" and brought about concerns related to the trust in more natural convictions over technical tactics. Alder (1997) provides

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[42] Martins (2011, 2013, 2016) investigated the historical and political contexts of art education as a tool for social control and governance. In "From scribbles to details" (2011), she analyzed the use of stage theories of drawing to regulate and normalize children's artistic expression. In "The arts in education as police technologies" (2013), she explored how the arts shape the moral and emotional development of children within broader systems of control. Finally, in "The «Eventualizing» of arts education" (2016), Martins advocated for a critical approach that engages with the social and political dimensions of art and culture beyond technical skill-building.

another example citing trained gunners on the battlefield utilizing their natural eyesight and a mathematical table to fire upon an enemy[43]. Like the gunner, the artesian has particular ways of making things work. This point seems to counter the efficiency and precision goals of the Gribeauval system.

2.11 The Gribeauval System and the Technical Life: Engineering, Meritocracy, and Control

While the machination of production would become a political battle in France during the French Revolution, the mobility of ideas like interchangeable parts in production raced across the Westernized world. For instance, the United States took on the concept of interchangeable parts in manufacturing and developed it throughout the first part of the 19th century (Alder, 1997). According to Alder (2010) in Engineering the Revolution, the reliance on engineers in France during the Industrial Revolution was based on a trust and vision of a systematized and scientized ideology of social values and localized control. Alder (2010) argues that the engineers, no less than the Revolutionary politicians, promised to remake the world in light of present circumstances and aimed to reorder the social world. They introduced new codes to guide the designing, making, and using of material things and placed values such as "efficiency" and "control" in the service of the new sovereignty. New institutions were devised to nurture these

[43] For a fictional example, one might recall Luke Skywalker turning off his targeting computer at the Battle of the Death Star in Star Wars can be related to Alder's (1997) example of trained gunners on the battlefield utilizing their natural eyesight and a mathematical table to fire upon an enemy. Both instances highlight the importance of human expertise and intuition in combat situations and how relying solely on technological systems may not always lead to the desired outcome. Similarly, the artisan's particular ways of making things work, as mentioned by Alder, emphasizes the importance of individual skill and creativity in contrast to the rigid efficiency and precision goals of the Gribeauval system.

values and the engineers made them appear universal or necessary to the new national sovereignty (Alder, 2010, p. 346).

Gribeauval's innovation was not only limited to material goods and weaponry but also included an expansive training regimen and an intensification of educational requirements for those interacting with the materials and overseeing the production of his artillery (Alder, 2010). This regimen provides glimpses into the ways in which present-day default justifications occur by means related to technologies of the material world and those who support and produce such things. Employing what Alder (2010) calls the technical life, such appeasement of the masses seems to have been rooted in Gribeauval's system and the diminishment of explicit sovereign rule. The Technical life (Alder, 2010) is a coherent social and ideological world that gives purpose and meaning to a set of material objects. The Gribeauval system fulfilled the will of the Sovereign through a mediated scheme of tangible material technologies of a new military system to please the subjects. The new weapons systems were complex in their ability to defend, assault, destroy, and overpower. Production and weapon products were precise, efficient, and effective in the eyes of military expertise. As Alder (1997, p. xxi) states:

> Their efforts oblige us to confront a rather different relationship between technology and politics: not simply because these guns were put to destructive ends, but because the means of creating these guns and the meanings invested in them depended on a distinct form of the "technological life." New kinds of technical knowledge and innovation permeated the lives and materials of society. The engineers' technological life revolved around managing large systems of workers, soldiers, and weapons; it presupposed new forms of technological knowledge and innovation. It was energized by a radical ideology that justified social hierarchy regarding national service (Alder, 1997 p. xxi).

Alder (1997) argues that the modern era and the place of engineers and engineering have their establishments in the micro and macro interactions within this network. However, this time would bring seemingly nonsensical paradoxes of engineered and the engineering which, through specific lenses, are visible today. Engineers would be creative and measured, self-disciplined and controlled, boundless and bounded.

Gribeauval's wartime ideals emphasized the importance of discipline and a "technical life." The establishment of schools offering top-notch scientific and technical education was crucial in providing soldiers with the necessary skills to operate the new equipment on the battlefield. Those who served in the system were expected to be cooperative in achieving the state's objectives while being evaluated based on their abilities (Berkowitz & Dumez, 2016). Notably, individual achievement was vital, but it was also viewed as a collective effort.

Alder (1997) elaborates on this new way of life, which involves a paradoxical allegiance to corporate service and individual preferment. The goal was to create a self-disciplined individual whose institutional environment was described by Max Weber, and whose anatomy was examined by Michel Foucault. The highest ideal was service, and modern professions exist in a peculiar panopticon called meritocracy. In time, the concept of meritocracy evolved beyond mere standards and actions, extending to include ways of behaving, influencing, and carrying oneself. According to Alder (2010), engineers were expected to adhere to a professionalized playing field that incorporated the tropes and attitudes of business derived from the teachings of Calvinism and the Protestant work ethic while serving as an example for society as a whole. The successful engineer, therefore, was not only considered competent in the contents of science but also served and led in a way perceived as progressive or democratic. This notion of meritocracy was shaped by identifying and valuing specific traits and utilizing expertise and social trust to achieve specific goals. These goals were established and enforced by individuals such as Gribeauval and his trusted officers, acting in the confidence of, if not exactly, in the king's name (Alder, 2010).

Cech & Secules's (2019) work on engineering education reflects this attitude as they explore how the formation of subjectivity is shaped by institutional practices and cultural norms within the engineering profession. Their work highlights the ways in which engineering education can perpetuate a narrow and exclusionary understanding of what it means to be an engineer, which can limit the diversity of perspectives and experiences within the field. Similarly, localized institutional practices of educational classification, promotion, and tiered instruction can reinforce narrow ideas of meritocracy and perpetuate systemic inequalities. The goals set and enforced by people like Gribeauval and his trusted officers in the confidence of, but not quite in, the king's name illustrate how power dynamics and cultural norms shape institutional practices and the formation of subjectivity.

Success and discipline were directly linked to loyalty to the Sovereign in the past, but this has changed with the rise of meritocracy. According to Alder (2010), engineers are now promoted based on institutional standards and expertise, as well as their service to society. Gribeauval's artillerist is an example of this shift, as they depended on localized institutional places and people for advancement, replacing the king as the abstract representation of the state. This new system of meritocracy is based on technical competence and is different from the previous one, which relied heavily on seniority. As MacLennan (2003) notes, Gribeauval added an element of peer review to the promotion process and instituted limited promotion from the enlisted ranks. With this change, new ways of measuring, assessing, and sorting individuals came into play.

Individuals were expected to complete a demanding series of classes across various disciplines to stay true to the values of the "technical life." Geometry was said to have provided the "cognitive and social framework" for this system, along with courses in engineering theory, physics, and military history (Alder, 1997, p. 88). These courses created a common epistemology and vocabulary among students, allowing them to practice scientific and war discourse. Material sciences were also part of the curriculum, with courses related to the physics of wood and metal, metallurgy, mechanics, smelting, draftsmanship, and typography (Berkowitz & Dumez, 2016). In these topics, the split of science's technical and methodological epistemologies began to split from what some might call the more "intellectual" work, which affects hierarchies in scientific communities (Latour & Woolgar, 2013). The separation of scientific disciplines and the sense-making process involved in technical understandings and applications come with the split of methods. The system enforced a strict disciplinary code emphasizing punctuality, proper dress, and complete silence. Senior artillery officers were present to ensure discipline and could even detain or imprison students. This power dynamic allowed for significant influence over the development of students. Alder (1997) observes that this system employed a technique of discipline that relied on the teaching of irrelevant or unnecessary knowledge to occupy the time and minds of students, thus fostering endurance, rigor, and perseverance.

2.12 The Gribeauval System: Surveillance, Discipline, and Control

The modern engineer experience seems similar to those who worked within Gribeauval's system. The system impacted how students were sorted and regimented within the school. It would affect their placements within the military ranks based on mathematics-based assessments, which frequently were more disciplinary than practical (Bien, 1969). Alder (1997) connects such disciplinary actions to the Gobelins tapestry school described in Foucault's Discipline and Punish (1975). Pedagogues in the school insisted on disciplining the artisans' children by utilizing drawing lessons to busy them and to incorporate a way of organization of thoughtless practice in the practical work of their cultures. Conversely, children with "proper" attitudes worked alongside master craftsmen gaining practical skills (p. 66). Such disciplinary actions favored ways of thinking, controlling, and shaping the mind and the will of the individual, making promotion a product of determination over practice.

According to Alder (1997), Gribeauval's students, like the Gobelins students from Foucault's analysis, would be under a similar form of surveillance by writing, "Living continuously under the scrutiny of this gaze, the students in time would come to internalize the markers of merit, and so become modern self-disciplined individuals (Alder, 1997, p. 66)." The gaze within the Gribeauval system came from non-military professors and enforcers entrusted with a uniform curriculum, one that taught the "common language" of the corp. By common language, I refer to a language related to engineering processes, materials, and problem-solving methods, amongst other things. Deviation from norms was to be admonished. Even deviant professors who would dare stray from regimented problem-solving techniques were reported to Gribeauval and reprimanded. Alder (1997) adds, "The intention was to impose a uniformity of habit and thought, instilling a solidarity that was the technicians' equivalent of esprit de corps (p. 67)."
Schools were centered on mathematics, a subject that acted as a "gatekeeper" between engineers and laypeople (craftworkers, artesian, and the like). In a society bound to ideals of democratization, the citizenry held power over those like the modern engineer whose

responsibility to the hopes, salvation, and safety would, for better or worse, create strict benchmarks for engineers and their level of expertise (Alder, 1997)). Often such benchmarks had little to do with applied engineering but created ways to sort using discipline beyond the necessary knowledge. Along with impractical math, technical drawing was also a sorting mechanism.

Under Gribeauval, drawing was considered a normal part of the engineering process, and the standardization of drawing methods provided a new form of discourse in the engineering realm. As a result, technical drawing became a gatekeeper to certain statuses, levels of expertise, and rankings of people and institutions within the system.[44] It implied a certain level of obedience, discipline, and cognitive ability. Alder (1998) stated, "In this way, mechanical drafting defined the social role of engineers in late France as the designers of artifacts, placing them as intermediaries between state patrons and artisans: vis-à-vis patrons, projective drawings created a legally enforceable standard which made them accountable to their superiors" (p. 516). Gribeauval created an exceptionally detailed five-volume set of engineering diagrams called the Tables de Construction, which provided drawings of his military components. These illustrations were a reference for the accounting and positioning of every detailed part of each of his designs. The technical drawings in the Gribeauval System were not only tools for controlling production but also a means of discipline, training, and reproducing material goods. The Sovereign approved the standards communicated in each drawing and enforced through tight tolerances and

[44] Lacuee's (in Alder, 2010) critique of Gribeauval's training regimen questioned the system's focus on drawing and mathematics classes for cadets interested solely in the infantry. Instead, he proposed an examination-based system, similar to that of the artillery, to establish a hierarchy in engineering. Lacuee believed that exams were the fairest way to prioritize the selection of officers and that talent and virtue should be the only criteria for public positions. This idea of expertise within the technical program could shape the rationalities for professional and academic exams.

uniformity. Jasanoff (2015) notes that technical drawers must mistrust their eyes, hands, and judgment and commit to rendering "thick objects" defined by engineering practices.

However, technical drawing was not just a technology for disciplining others but also a means of disciplining the self. Math-heavy and technical drawing-centered education provided new social spheres within the military where particular forms of knowing, disciplined through schools, created power relations within the ranks. With such uniformity, rules of engagement did not require human intervention, as disciplined subjects would anticipate and follow orders.

The Gribeauval System acted as a regime of surveillance, knowledge, and control, where self-discipline was expected at all levels. As Alder (1997) notes, the system was a paradoxical allegiance to corporate service and individual preferment, creating a self-disciplined individual whose highest ideal was service. The adoption of technical drawing turned it into a technology for reproducing material goods and a means of discipline and control within the Gribeauval System. According to Alder (2010), using Foucauldian Analysis, self-discipline from outside cognitive programming provided a place of possibilities for engineers to be authoritative and flexible.

While passing through "kept gates" of mathematical proficiency created a certainty of competency, the practical application of mathematics and other disciplines became necessary. "Even the artillery examiners agreed that memorizing formulae was less important than teaching students to use mathematics to appreciate the relative importance of facts (Alder, 1997, p. 68)." Gribeauvalists ignored the best scientific knowledge of their day. Instead, their design reflected their technological life, in which expertise would be re-founded on new engineering knowledge based on material objects. It was a more efficient, practical, and controllable mode. French engineers were not theory dependent. Instead, they depended on battle-ready wits, flexibility, and discipline. "Their activities could not be reduced to equations or rigid routines. As members of a quasi-noble profession who inflicted death at a distance, the artillerists also insisted on their autonomy as experts to exercise their discretion (Alder, 2010)." In this sense, mathematics became a discipline of order, judgment, and problem-solving rather than one of specific technical use. As Rose (1996) claims, the process consists of 'the translation of political programmes articulated in rather general terms—national efficiency, democracy, equality, enterprise—into ways of seeking to exercise authority over persons, places, and activities in specific locales and practices.' The sorting and resorting regarding mathematic proficiency created a hierarchy within a hierarchy bringing into the fold different sorting mechanisms through particular disciplines and creating types of people, equipment, and materials that would become part of the "technical life."

2.13 The Gribeauval System and the Shifting Dynamics of Sovereign Power

As often happens in hierarchies, credit would go to those at the top while assemblages of human and non-human factors do all the work (Latour, 1989; Asdal et al., 2007); see also Collins & Pinch (2014); Shapin & Schaffer, 2011). Expertise involves the trust of those who deem such things, successes, and the competency and control of particular technologies. It helps to have marketing skills and influence over the influencers. For example, in the debates between Robert Boyle and Thomas Hobbes, Boyle's marketing of the air pump, amongst other things, gained influence in The Royal Society of London for Improving Natural Knowledge (Shapin & Schaffer, 2011). Expertise has dramatically expanded its role in the technologies of government.

MacLennan (2003) states, “The Gribeauval system . . . embraced the risk of battle and accepted the possibilities of open-ended destruction, and it brought a radical functionality to its purpose of providing mobile firepower (p. 259).” This shift away from the show of sovereign power gives way to warfare based on expertise in technologies regarding design, implementation, and tactics (Madhavan, 2015).

At this time, the idea of expertise provided a form of rational trust and practical tools to present a vision of and commitment to progress based on science instead of otherworldly interventions (Smith, 2020). Modern political rationalities have relied on expertise—from the earlier masters of 'statistics' to the later social scientists. However, the experts have tended to be permanently or temporarily in-house—public servants or experts serving on public policymaking inquiries. In this case, the experts, such as today's ubiquitous management consultants, are more likely to be 'autonomous' as they relay and translate the government's priorities in various locales. Their pretensions to autonomy, disinterested rationality, and scientifically established truth claims simultaneously endear them to private and public interests.

As nations recognized the significance of new technologies and science for their success and security, the public demanded their development, resulting in new standards, knowledge, and discipline for scientists and engineers (Barry et al.., 1996). Within the Gribeauval system, discipline and surveillance were no longer the direct tools of the Sovereign. Instead, centers of authority acted as intermediaries between the state or sovereign rule and the subjects who were entrenched within them, enabling more localized and internalized means of control (Asdal et al., 2007). Experts in charge of training artillerymen and backed by the Sovereign to achieve technological progress created a range of systems, strategies, and devices that embedded particular values and ways of living, which are now considered normal and commonsensical. As Foucault (1975) contended, the Sovereign's force exerted on the body has shifted into the discipline of the self by the self and other atomized units.

The political transformations during this period were complex, with various factors contributing to the shift towards merit-based production, trust in technology, and enlightenment rationality, which impacted not only science but also society and politics (Alder, 2010). Gribeauval's system marked a significant moment in this shift, moving away from a centralized sovereign power and introducing tactical changes to the way battles were fought. Unlike earlier systems that relied on traditional siege warfare, Gribeauval's system offered a more practical and holistic approach, enabling tactical changes that moved away from the conventional display of centralized power (Berkowitz & Dumez, 2016).

Before the emergence of the Gribeauval system, the preferred strategy was siege warfare, which was conducted in a methodical and coordinated manner. MacLennan (2003) notes that in the system Gribeauval replaced, "(The) Valliere system treated war almost as a form of theatre: a display of sovereign power in a controlled setting, with the destructiveness of warfare, bounded both by conventions of behaviour and by physical laws.” This warfare type incorporates what Alder (1997) refers to as "War as Theatre," or an explicit demonstration of the Sovereign's power. "War as Theatre" is based on hierarchical traditions, behaviors, and technologies, beginning and ending with the sovereign (Madhavan, 2015). With the show of might came the sluggishness of large guns and their supporting bodies. The equipment was too heavy to move quickly in the field, and there needed to be more uniformity, making production and repair chaotic. Gribeauval's system was able to engineerize war through science, technology, and the social-political wants of efficiency and mobility, making guns and artillery nimble and offensive, thereby changing the way war was considered and strategized. Enlightenment reformers argued in favor of Gribeauval's system, not just for the sake of winning battles utilizing offensive over siege strategies; they were looking to redefine the sovereign–subject relationship or, as Alder (2010) puts it, "they were overturning one of the core definitions of the kingdom." The idea of "kingdom" as an area of authoritative rule shifted to a form of self-governance through and within subjects occupying the same regions.

The power of the sovereign shift to power to the people indicates a change in the ordering of minds and futures rather than unquestioned loyalty to a king. Sovereign power would indirectly influence society through institutions and technologies of discipline in reaction to a society’s newfound packet of freedom and thought. Newfound because the power transition became located on the individual soul where freedom seemed new. Packet because of its parceled and delivered orders from new social and political entities. The king's trust in the technical abilities of engineers enabled them to become a trusted representative of the Sovereign's power. As MacLennan (2003) notes, engineers were authorized and trusted by both the sovereign and the subjects, providing them with the flexibility to control the context and content of innovation, ultimately resulting in a technical network of control at a localized level. Gribeauval's system aimed to create weapons that were not only effective for siege warfare but also mobile and agile, allowing for both offensive maneuvers and retreats to defensive positions. This change in warfare, as noted by Berkowitz and Dumez (2016), necessitated greater mobility and firepower, resulting in the high casualties seen during the Revolution and Empire. Furthermore, the integration of the artillery corps with other army corps for maneuvers marked a significant organizational change.

According to Alder et al. (1997, 2010), Rothenberg (1980), and MacLennan (2003), Gribeauval's new weapons were made lighter and more maneuverable by removing royal ornamentation, resulting in greater accuracy and efficiency. Alder (1997) suggests that the removal of royal ornamentation reflects a modularization of power within a technocratic hierarchy connected to Gribeauval's organization. However, Madhavan (2015) argues that the focus was on agility and the ability to produce and transport better artillery. Alder (2010) sees the removal of royal ornamentation as symbolic of the demise of dynastic warfare and the rise of nationalist warfare.

Removing royal ornamentation from Gribeauval's weapons not only resulted in a redesign of the weapon's physical dimensions but also reimagined its use and altered the social dynamics among its operators, illustrating how artifacts are political and can alter the distribution of power (Alder, 2010). This shift in power is integral to the development of the engineer's revered status in modern history, creating a structure of discipline, control, and surveillance that we still see in modern military organizations.

According to MacLennan (2003), the Gribeauval system extended beyond the development of battle instruments crafted from wood and metal, becoming a belief system that was integrated into the human body. The system's engineering and production regulations served as systems of discipline inspired by the works of 17th-century military reformists Maurice of Nassau and

Gustavus Adolphus of Sweden. The Gribeauval system's training and educational regimes were structured and disciplined, emphasizing the intersection of technology and power within a social system. Furthermore, the production of battle instruments gained a new level of significance.

The Gribeauval system facilitated a peaceful change in the relationship between the ruler and the people by leveraging technological expertise and promoting prosperity. According to Rose & Miller (1992), expertise, which encompasses a complex network of actors, powers, institutions, and knowledge, has become a crucial factor in establishing the legitimacy and possibility of government. By relying on experts, the government can resolve regulatory problems without getting bogged down in political disputes and instead focus on objective truths. Moreover, this approach enables the government to install self-regulatory techniques in citizens, aligning their individual choices with the government's objectives. Consequently, citizens' freedom and subjectivity can become an asset, rather than a threat, to the orderly governance of society.

Foucault (1975) observed that the distribution of sovereign power across different entities has evolved into a means of discipline and surveillance. As scientific knowledge became more systematic, the locus of discipline and rule shifted from the top-down approach to individual-level control through technologies and designs. Although it appears to relinquish power, this shift actually centralized more power in the state through surveillance, self-regulation, and self-discipline. In exchange for practical and rational solutions that benefit the people, citizens surrender some autonomy to the state.

2.14 Gribeauval's System: Engineering, Power Shifts, and Disciplinary Actions

For Gribeauval, engineering was not simply about manipulating materials but also about shaping the workforce. Gribeauval's system demanded a thorough understanding of and adherence to specific military operations, leading to remarkable successes and resulting in the reorganization of command within the French Army. As MacLennan (2003) notes, the artillery's mission became the driving force behind the organization, promotion, tactics, technology, training, and even production in the Army. Gribeauval's system gave him the authority to not only define the material aspect of engineering but also to establish the means and constraints for selecting worthy engineers, including peer review in the promotion process and limited promotion from the enlisted ranks, along with testing, training, and rubrics.

This structure created a new way of viewing workers based on technical abilities instead of craftsmanship. It incorporated the use of a system, peer review, competency assessments, and ideas of efficiency and precision. As a result, success in engineering during times of war became increasingly reliant on individuals with these technical "types" of abilities, who were disciplined in employing STE assemblages at the behest of the Sovereign.

From these power shifts and alliances of science, sovereignty, and subjects, assemblages form around the hopes and fears of society and the need for a reordering of discipline and mindsets. The Gribeauval system was promoted to French leadership through a need for transformation paired with a gaze toward the future. With the French Military losses fresh in the minds and new attitudes toward science as a means of rational design, the time seemed right for a systemic change (Alder, 1991; Alder, 1997; Alder, 2010). However, the physical forces of war that brought the power of Gribeauval's system became vital to ways of thinking about systemizations involving more than just the military. Science, technology, engineering, and individuals within a society would become part of the system. The body, mind, and soul would become possible places of intervention based on scientific "truths" and management. Individuals committed to a technical life in a technoscientific society would learn how to reform the ways of doing, seeing, and creating at the whim of scientific experiments, expertise, and a progressive attitude. However, within this context lie questions about particular assemblages concerning the formation of complex systems, shifts of disciplinary powers through technologies and expertise, and the transfer of discipline onto and eventually into the body by assumptions of mechanical understandings and assemblages (Asdal et al., 2007).

Gribeauval's system trained experts, not artisans. Experts focused on particular parts and methods within production instead of the craftsman whose work was holistic and whose production saw the making of the product from beginning to end. This vision of training experts was radical as it upset the norms of social and political service structures, forming a more efficient and standardized "merit" system based on what was considered technological competence and a "peer review" process to assure a certain kind of mindset (MacLennan, 2003). This structure, in turn, formed a self-disciplinary system of perceived competence, standards, and ways to behave as a means to organize individuals and their levels of expertise. The training and discipline programs which grew from the system seem to have the effect of engineering the engineers, designing the designers, or disciplining the disciplinarians. This reapplication of methods through structured disciplinary actions along with technoscientific blending suggests the potential for a point in time where objectification and subjugation through science, technology, and engineering authorities along with the obscured power of sovereign acting through authorities of the likes of Gribeauval.

2.15 The Technocratic Revolution: Power and Expertise in Science

Gribeauval's system also played a significant role in creating new types of people, value systems, and disciplinary technologies, as noted by Alder (1997). The deployment of this system led to changes driven by technological promises, trust in science and engineering, and a mapped progression, all contributing to what Alder calls a "Technocratic Revolution." This revolution was based on the idea that expertise, particularly that of engineers, was rarely questioned. Their power came from a "technocratic pose," using the ideals of technology to normalize the impression that progress through technological means was natural and inevitable.

This approach valued and evaluated workers based on technical ability rather than craftsmanship and artisanal efforts. It incorporated a system of measurement, evaluation, and other enlightenment-adjacent truth regimes, including peer review, assessments of competency, and ideas of efficiency and precision. Experts within these systems provided visions of progress, prosperity, and salvation through the technocratic revolution. This shift led to the development of a self-disciplinary system of competence, standards, and ways of behavior, organizing individuals and their levels of expertise.

What is noticeable is how power becomes embodied in specific organizations, standards, tools, and systems and thus becomes a means of ruling through the unification of ideas, materials, and expertise rather than a centralized authority. These systems are based on progressive thought and engineering principles that contribute to the expansion of scientific discovery. To understand the relationship between rationality, science, and technology, we can look at the ideas of Bacon and Descartes, who shaped the representations of these concepts through different social and political power influences. Baconian philosophy states that power is achieved through success in science, and modern science emphasizes quantification, power, and rationality as opposed to a state of being. Science is used to dominate nature by reducing it to controlled experiments and mathematical descriptions. The modern scientific paradigm aims for specialization to mitigate the uncertainties of the spatiotemporal discovery process. Specialization organizes knowledge around particular paradigms, resulting in different understandings of concepts like energy across scientific disciplines. Knowledge is negotiated and preserved within specialized domains, with experts and communities of practice forming truths based on professionalism and expertise. This point disperses power from a centralized location to numerous disciplines, subsets of disciplines, and all those factors that influence each subset through disciplinary and inclusionary practices. In summary, this suggests a power/knowledge basis of epistemologies of science in society, formed through diffused disciplines and desires.

The Gribeauval System was instrumental in defining technoscientific practices, winning public support, and subjecting bodies and minds to new modes of engineering. His success in terms of socio-political power included the transition of sovereign power towards a more disciplinary form accepted as part of national pride, salvation, and economic interests. The Gribeauval System would be essential to industrialization and the control of worker bodies and minds. The progression away from the artisan towards the unskilled worker would become the core of economic advancement throughout the Westernized world. Soon all manufactured works (though slow to happen in France) would begin to acquire and use systems that looked like the Gribeauval system (Hopp, 2018). Though many aspects of Gribeauval's system would move outward into Europe and North America, much of the industrial-related production systems derived from Gribeauval's innovations would meet resistance in and after the French Revolution. As a result, the technologies that reconstructed France into one of the most potent military powers of the time would form universal norms in other places where these technologies would seed economic and political successes. While the machination of production was a political battle in France that was problematic in this period, the mobility of ideas like interchangeable parts in production raced across the Westernized world. [45]

2.16 Taylorism, Industrial Psychology, and the Engineering of People

The rest of the Westernized world was finding new centers of power with economic advantages. Nations were restructuring the social order by universally applying engineering practices and values. Values such as efficiency and control were used similarly to materials, production, and bodies to consider the future of a reemergent society. These values soon appeared across Europe and the United States as the basis for concepts like Taylorism and Industrial psychology. Taylorism is related to the idea of scientific management forms, mainly used in pursuits of efficiency and rationality. The process often includes the human body and its abilities and limits as part of its management scheme. Industrial psychology is an applied form of psychology that considers human attitudes, behaviors, and functions as they exist in the workplace.

[45] DeLanda (2015) describes how American visitors, particularly Thomas Jefferson, were interested in innovations, such as the interchangeable lock components of Blanc's muskets. Eli Whitney learned of Blanc's work through diplomatic exchanges and attempted to emulate it in his musket contracts with the War Department. While Whitney failed in this endeavor, he became a proponent of the uniformity principle. He popularized the concept, persuading politicians to support standardization in manufacturing military arms.

Entering the age of Mass Production (Holtcamp, 2003), an age that coincides with the Industrial age, efficiency and management becomes essential. The step removed from science towards modern engineering streamlined manufacturing by standardizing parts and assemblies, managing quality by employing data collection, measurement, and assessment, and disciplining bodies and minds through kinesthetic control and persuasive selling or marketing. Industrialists like Eli Whitney, Samuel Colt, and Henry Ford utilized these manufacturing and promotional ideas to build reputations associated with modern visions of capitalism and marketing, which still exist in some form. Economic safety and prosperity joined the safety and comfort of military-related pursuits utilizing similar means of engineering machines and products and using science and engineering as a means to discipline bodies and minds. The mechanization of science employing engineering on assembly lines and in production systems would pull the bodies of individuals into the system. Ideals of economic progression and American exceptionalism began to gain footing around models of Democracy, efficiency, and Imperialism. Central to these ideas would be functions of work ethic, good citizenship, and the pursuit of individual prosperity. Fredrick Winslow Taylor and progressive influence just after the turn of the century would create an atmosphere where the body can be brought into a system as productively and efficiently as an interchangeable part, tool, or machine.

The Westernized world was undergoing a transformation as new centers of power emerged, driven by economic advantages. As a result, the application of engineering practices and values to restructure society was becoming universal, with efficiency and control guiding decisions about the future. These values were adopted across Europe and the United States, forming the basis for concepts such as Taylorism and Industrial psychology. Taylorism focused on scientific

management, aimed at optimizing efficiency and rationality, and often involved managing the human body and its abilities as part of the process. Industrial psychology, an applied form of psychology, considers human attitudes, behaviors, and functions in the workplace.
According to Leonard (2016), Taylorism was embraced by progressive thinkers during the industrial era as it placed workers and science in opposition to unfair labor practices and industrialists. However, during its popularity, Taylorism was seen as a means of control in U.S. manufacturing and was managed by a specially trained "Elite corps of experts." The prophecy of these engineers becoming an industrial "General Staff" that would eliminate the shameful waste of profit-seeking capitalism provided hope and fantasies in technocratic circles of increasing U.S. industrial output by 300 to 1,200 percent. Nevertheless, this process did not work as intended.

Workers and experts, such as industrial engineers, found that the promise of more money fell short of the surrender of bodily autonomy of the laborers (Leonard, 2016). The impact of mechanization and division of labor during the Gribeauval system in weapon factories was increasingly evident in other industrial entities. However, the outputs of these factories did not necessarily reflect the inner mechanisms and human spirit of the means of production itself (Foucault, as cited in Delanda, 2015a). The problem of legitimacy faced by factory workers was more related to controlling their actions than losing power (Foucault, as cited in Delanda, 2015a). This control was enforced through the concentration of knowledge at the top and the routinization of activities at the bottom, making the authority of officers and supervisors more enforceable.

Even when procedures were optimized to reduce physical effort, the elimination of flexible skills and their replacement by rigid routines led to a net transfer of control from workers to managers (Delanda, 2015a). The result was a complex system of simplified tasks performed in modular parts and subject to strict quality controls. The actions and behaviors of disciplined workers were under the watchful gaze of factory masters who dictated workflow, and craft skills and other preindustrial traditions became a hindrance to production (Delanda, 2015a). Therefore, in such an environment, the engineering of people became just as important as the engineering of materials.

As the Industrial Age and Mass Production emerged, efficiency and management became essential. Modern engineering streamlined manufacturing by standardizing parts and assemblies, managing quality through data collection and measurement, and disciplining bodies and minds through kinesthetic control and persuasive marketing. Industrialists like Eli Whitney, Samuel Colt, and Henry Ford utilized these ideas to build reputations associated with modern visions of capitalism and marketing. The use of science and engineering to discipline bodies and minds was also employed in military-related pursuits. Economic safety and prosperity became intertwined with the ideals of democracy, efficiency, and imperialism. Pursuing individual prosperity, good citizenship, and a strong work ethic were central to these ideas. Progressive influence, such as that of Frederick Winslow Taylor, created an environment where the body could be brought into a system as productively and efficiently as an interchangeable part, tool, or machine.

There seems to be a noticeable shift from a pure form of capitalism where wants for freedom and autonomy surpass monetary compensation. In this space, engineering might be thought of in modernity as a way of providing liberty in forms of space and efficiency as in household appliance design, transportation as in automobile production and ownership, and other leisures borne from technological advancements. Delanda (2015b) states, “By the late 1850s, the basic components of the American system could be found in organizations producing everything from sewing machines, pocket watches, and railroad equipment, and later on typewriters, bicycles, and many other machined metal products.” Efficiency and speed created tedious and poor working conditions. They also created high rates of production and opportunities to make more money based on such production. Monetary incentives were used to alleviate the monotony of work and provide opportunities for leisure and convenience as a form of reward, such as being able to purchase a Ford Model T "horseless carriage" (Hopp, 2018).

The motivation to perform a job was transformed into a measurable concept based on speed, efficiency, and discipline, which held actual material value (Hopp, 2018). As humans, machines, and materials are organized into systems of production, new regimes of truth emerge based on assembling, evaluating, and reassembling worker-involved systems. While these regimes have been labeled in various ways, those working closely with scientific disciplines tend to agree on frameworks that prioritize system inputs and outputs in service to the next "customer" (Hopp & Spearman, 2004). Additionally, the system influenced ways of thinking about the human body and soul as being mechanized and to be fixed by employing science, technology, and engineering methods.

2.17 Mechanized Ideals: The Human Machine and Assessing Bodies, Minds, and Souls

The mechanized ideals that emerged paved the way for solutions to issues related to the body, mind, and soul through interventions based on measurements, assessments, and categorizations. However, this approach is disconnected from the natural state of being and seeks to sort and "fix" specific concerns rather than embracing complexity and diversity (DeLanda, 2008). For example, when psychologists, sociologists, or medical experts use scientific methods and technologies to collect measurements and define pathology from a particular vantage point. This cause-and-effect analysis, often applied to mechanical systems, is also used to create interventions for more complex systems involving populations, minds, and souls, marginalizing irrational considerations. As engineering and technology progressed, such concerns, once limited to inanimate materials, began to be applied to human bodies, minds, and souls.

By assessing through inputs and outputs, processes in between become scrutinized, not utilizing the capacities of human limitations but by ideals, exemplars, and standards based on statistical averages and scientific equations. Such complex convergences offer a way to consider how the worker-machine   The assembly moved towards a form of production that was efficient, precise, and disciplined. Observing this only from outcomes neglects how and to what extent work is performed by humans, machines, and combinations of both. This last point allows for the existence and normalization of the human body-machine assemblage as an acceptable way of thinking about the mechanism of both the material and non-material parts of the human body. The notion that the human body is a machine has been present for centuries, with Descartes and La Mettrie both subscribing to this idea. La Mettrie's L'Homme Machine (1748) even argues that the body is a machine with a self-winding mechanism and denies the existence of the soul, calling it a "chimera" and an "empty word" (Offray de La Mettrie, 1961, p. 141). This mechanistic portrayal of humanity has also been reflected in Hollywood, as seen in Charlie Chaplin's film Modern Times, where workers are depicted as mere "cogs in the wheel" (Synnott, 1993).

Early child-rearing practices in the early 20th century were similarly mechanized and regulated, with experts controlling everything from a child's eating and sleeping habits to exercise and bowel movements. Some child-rearing books even suggested training children to be "efficient little machines" for the benefit of their mothers (Synnott, 2002, p. 36). However, in the mid-20th century, child-rearing author Dr. Spock advocated for a more humanistic approach, advising parents to interact with their children lovingly and playfully alongside providing them with necessary nutrients (Synott, 2002). This shift marked a departure from the punitive methods of child-rearing and prompted reflection on the potential harm of such practices on children and the credibility of experts.

Despite these shifts, societal divisions still uphold disciplinary and regimental practices, often relying on biblical teachings to disconnect children from their bodies (Synnott, 1993). The potential for scientific control over the body, soul, and materials has led to the idea of assembling, disassembling, and reassembling these components to predict and prevent the unknown (Synnott, 2002). Synnott (2002) also questions the drastic change in the sensorium during this period.

An example of this reassemblage is Nolan's (2021) concept of the Ergonomics of the Spirit. In this context, assemblages are utilized to construct new truths by designing and employing a human cognitive apparatus based on technologies of production, consumption, and governmentality. As noted by Nolan (2021), the ergonomics of the spirit implies a cartography of cognitive difference that rests on the primitive as the primary object of evidence from which to extrapolate theories about the mechanics of human intelligence. This approach differs from bodily ergonomics, exemplified by industrial Taylorism, which presupposes the basic fungibility of human bodies. Thus, there is potential for an objective mapping and analysis of the brain, akin to Taylorism's management of the body. This possibility opens the potential for scientific and engineering souls based on differences across a continuum. Like recapitulation theory, in which sorting exists through perceived progress towards the exemplary, Nolan's (2021) theory posits the existence of certain maturations of things like intelligence, aesthetics, and creativity. However, the deployment of such an assembly enforced particular problems due to categorizations based on race and gender, especially with biases of what counts as advancements embedded in certain spirits.

This section focuses on the significance of the Gribeauval engineering system in the history of engineering. The establishment, refinement, and mobility of this system played a crucial role in the development of specific methodologies, standardizations, and quality controls. However, the impact of the Gribeauval system extended beyond the control of materials. It also encompassed the control of bodies and souls, serving as a means of large-scale power for national interests. The system's significance lies not only in its technological advancements but also in its broader social and political implications.

2.18 The Gribeauval Engineering System and the Creation of Scientific Kinds

It is vital to emphasize the significance of the Gribeauval engineering system in the history of engineering. It marked the beginning of a transformative way of thinking that required changes in military doctrine, industry, and techniques (Berkowitz & Dumez, 2016). The standardization, production techniques, and applied science training of the system are reflections of the modern engineer and the process of engineering, which involves adherence to standards and methods as they exist in the present (Cowles, 2016). Today, this way of thinking about engineering is recognizable through the web of systems grounded in science and accumulated through connections with authoritative regimes. The Gribeauval system's influence on engineering practices is not limited to a singular moment in time and extends to different entities with specific interests (Berkowitz & Dumez, 2016).

The engineer is a "scientific kind" because they adhere to the standards and methods as they exist in the present and follow a methodology bound by those rational rules, often based on mechanical rationality (Cowles, 2016). This cumulation of scientized existence creates a particular "scientific kind" within created groups called engineers (Cowles, 2016). The process of creating "humankinds" involves the creation of "scientific kinds" that are turned onto themselves, creating complex forms of understandings or truths, as explained by a Looping Effect (Cowles, 2016; Hacking, 1995). This process is responsible for producing scientific kinds and ideas from scientific kinds and ideas, known as "Reflexive science" (Cowles, 2016). Reflexive science is "the usual method by which men have arrived at the principles" of science (Cowles, 2016, p. 724).

The idea of nature as derived and complexified through science, technology, and engineering is a mere placeholder for a way for a phenomenon to exist (Cowles, 2016). Systems derived from scientific, technological, and engineering methods blur the line between an interpretation of the "natural" and what "nature" is considered to be. The construction of nature makes this a less-than-ideal way to consider nature, and for this purpose, nature is proposed to be a phenomenon that lies in wait to be explained by the rational processes of science (Cowles, 2016). The Gribeauval system marked a significant moment in engineering history that influenced engineering practices across different entities with specific interests, and its impact is recognizable in the modern engineer and the process of engineering. The engineer is a "scientific kind" because they adhere to the standards and methods as they exist in the present, which is part of the process of creating "humankinds" through Reflexive science and Hacking's (1995) Looping Effect. The idea of nature is complexified by scientific, technological, and engineering methods and is best understood as a phenomenon waiting to be explained by rational processes of science.

2.19 STEM as a Solution and Concern

Gribeauval's system emerged as a response to France's military and national security needs, and its methods were later applied in other contexts to enhance efficiency in industrialization and production (Kelly, 2014). The shift in what constitutes national security has been observed in various countries, such as the U.S. during the Sputnik era and the release of the A Nation at Risk report, where the focus moved beyond missiles and tanks to include science, technology, engineering, and mathematics (STEM) and their impact on economic and cultural exceptionalism (Rudolph, 2019). Zheng (2021) notes that proposals for technoscientific systems to prevent a world crisis were made in the post-WW2 years, which became vital to global stewardship and national defense. The interplay of political, social, and technoscientific factors that could lead to a STEM crisis is discussed by Zheng (2021), who refers to it as a result of a designed utopia. The paradoxical nature of STEM, being both a concern and a solution to world crises, empowers those who control advanced technologies, knowledge, and practicalities and provides a cover of benevolence in the eyes of concerned individuals. Zheng's (2021) concept of 'earth as spaceship' helps bridge the gap between STEM and mathematics, with the latter being a discourse of science. This concept represents a fusion of intellect, vulnerability, and morality, and Westernized science has used it to perceive the actual reality of the earth. The concept of the 'earth as spaceship' has become a reference point for planning international education curricula and has created a system of powers where controlling futures, particularly world crises, is seen as necessary for salvation (King, 1971; Murphy, 2017, as cited in Zheng, 2021).

This mindset has led to the formation of assemblages responsible for acting rationally, responsibly, and even heroically to change the uncertain to the certain. The mechanical 'eye' from the moon has added a specific social demand for these reports, presenting the earth as a small, isolated, limited, and vulnerable system in the vast darkness of space, without any external input except for sunlight and with no clear destination (Daston & Galison, 2021). Zheng (2021) argues that this perception of the earth has conjured anxieties and fears about the threats that the undesired development of certain parts of the world might pose to those unprepared.

2.20 Conclusion

The emergence of modern practical science and technology has had a significant impact on shaping society, particularly in the field of engineering. The Gribeauval System, developed in

18th century France, played a crucial role in standardizing and organizing materials for military purposes, as well as in areas such as economic securities and industrialization. The Gribeauval System was innovative because it emphasized standardization and interchangeable parts in artillery manufacturing, leading to greater efficiency in mass production. It is said that the success of the Gribeauval System was due to the collaboration of engineers, entrepreneurs, and politicians, who worked together to improve the efficiency of the military and promote economic growth (Schaffer, 1993).

Gribeauval's contributions to the field of engineering and the military were significant in the 18th century, and they continue to be celebrated as heroic by some today. Gribeauval is often praised for his innovative ideas that significantly impacted military, economic, and management practices. His standardization of production methods and use of interchangeable parts enabled the mass production of artillery pieces, increasing efficiency and output (Schaffer, 1993). The impact of the Gribeauval System on the military was so significant that it was adopted by other countries, including the United States (Schaffer, 1993).

The engineering profession has been celebrated for its problem-solving abilities and contributions to society, with engineers often portrayed as heroes in the media. The heroism of engineers is often associated with their ability to solve complex problems and create innovative solutions to societal challenges. Gribeauval's contributions to the field of engineering exemplify the social influence of engineers and the significant impact they have on society (Kline, 2015). This representation of engineers as heroes has been influential in shaping the public's perception of the profession and has contributed to the increasing popularity of engineering as a field of study.

However, there is a need for a critical evaluation of the profession, acknowledging both its potential negative consequences and the need for diversity and interdisciplinary approaches to address complex societal problems. While the heroism of engineers can be celebrated, it is vital to recognize the limitations of this heroism to a narrow group of privileged, white male engineers (Kline, 2015). By calling for a more inclusive and equitable engineering profession, one that embraces diversity and acknowledges the broader social and cultural contexts in which it operates, we can ensure that the profession continues to evolve and address the challenges of our time in a way that is inclusive and equitable for all.

In conclusion, Gribeauval played a significant role in creating the aura of engineer as hero, exemplifying the social influence of engineers and the significant impact they have on society. However, there is a need for critical evaluation of the profession to ensure that it continues to evolve and address the challenges of our time in a way that is inclusive and equitable for all. Furthermore, the impact of technology and science on engineering has transformed it into a critical component of national interests, contributing to its globalization and socio-political influence. As such, we need to embrace diversity and interdisciplinary approaches to address complex societal problems and ensure that engineering continues to play a positive role in shaping society.

CHAPTER 3: The Mythology of the Rational Engineer and the Concept of Service to Humanity

3.1 The Mythology of the Rational Engineer and the Concept of Service to Humanity

The relationship between power, authority, and governance is complex and multifaceted, shaped by various factors such as mythology and rationality. In this passage, we explore the roles of mythology and rationality in shaping people's beliefs about power and authority, and how they contribute to the formation of a particular form of governmentality grounded in shared beliefs and values. Mythology, referring to stories and symbols that create a sense of collective identity, can be used to justify and reinforce certain forms of governance. Instead, rationality plays a significant role in scientific thought, creating systems of explanatory power, predictive power, and objectivity. However, the tension between science, non-science, and governmentality highlights the complex relationship between creativity, adaptability, and social control in shaping our understanding and interaction with the world.

Mythological elements have the power to validate and strengthen specific forms of governance by fostering a collective identity and a shared sense of purpose that can be leveraged to garner support for governmental policies and initiatives (Foucault, 1978). The emergence of the notion of private property, social duties, and family obligations marked a departure from a more disorganized cultural system to one that was socially demanding. This shift reflects the growing significance of virtues and morals in shaping individual behavior and expectations, ultimately leading to a move from physical coercion to psychological control (Gellner, 1992). As such, mythology is a crucial factor in establishing and preserving a distinct form of governmentality firmly rooted in shared beliefs and values.

Rationality shapes scientific thought and creates systems of and around rational scientific thought as a means of explanatory power, predictive power, and objectivity (Popper, 2015). This has been viewed as a universalistic force of judgment on validity over all local and temporal boundaries. The evolution of Enlightenment rationality can be seen as a form of salvation, replacing spiritual ways of sense-making. However, the tension between science, non-science, and governmentality highlights the complex relationship between creativity, adaptability, and social control in shaping the way we understand and interact with the world around us (Foucault, 1978).

In his seminal 1962 work "The Savage Mind" (La pensée sauvage), French anthropologist and philosopher Claude Levi-Strauss introduced the term "bricoleur" to the academic lexicon (Levi-Strauss, 1962). The term refers to a person who creatively uses available tools and materials to create something novel in contrast to adhering to a fixed set of predefined methods. Levi-Strauss's foundational work argues that human nature seeks to systematize aspects of life and society through creativity and problem-solving. As part of his methodology, Levi-Strauss studied how "untamed minds" interacted with and made sense of the material world. He also suggested that the bricoleur represents an emerging form of designer or builder similar to modern engineers, characterized by practicality, production, and social commitments (Nolan, 2021).

While the engineer works with a clear and predefined plan or blueprint, the bricoleur works in a seemingly less organized and planned manner. The term, grounded in the French language, pertains to a tinkerer, a junk collector, or a jack of all trades whose cunningness and deviousness are helpful in how he goes about odd jobs and temporary projects (Viveiros de Castro, 2019). In Levi-Strauss's research, the bricoleur is a non-westernized figure who works with materials and tools that are immediately available. There is no clear plan, as the bricoleur relies on a culturally bound commitment to creativity, adaptability, and intuition. The bricoleur provides a framework by which specific aspects of the modern engineer could be compared Lévi-Strauss (1962) proposed a classification of the development of the bricoleur and engineer, which provides a framework for exploring the potential ways in which engineering and the engineer (as well as the absence of engineering and non-engineers) were established in the latter half of the 20th century.

In the context of governmentality, the concept of the savage mind and the bricoleur can provide insights into how power and authority are constructed and maintained. The bricoleur's use of available materials and creative problem-solving can be seen as a form of resistance to established power structures while also being co-opted by those same structures to reinforce their legitimacy. In addition, it is possible to view the application of mysticism and symbolism in the context of the "savage mind" and the bricoleur's practices as a means of fostering collective beliefs and principles that can be leveraged to promote governmental policies and endeavors. The concepts of mythology, rationality, and the bricoleur offer valuable insights into how power and authority are constructed and maintained in society. By understanding these concepts, we can gain a deeper appreciation of the complex and dynamic nature of governmentality and the ways in which it shapes beliefs, values, and behaviors.

In this chapter, I explore the various perceptions of engineers and their processes, specifically in terms of their commitments to rationality, outcomes-based solutions, and abstract thinking. Drawing on social views and cultural references, I consider the bricoleur as an anti-engineer and compare the two in terms of their iconic representations and the discourses, values, and mindsets they define for emerging types. Viewed through the perspective of Levi-Strauss, the engineer is characterized by notions of advancement, redemption, and reliability, whereas the bricoleur is linked to cultural preservation, mysticism, and a mentality of "sufficiently good" approach. Mysticism[46] is seen as a natural part of human consciousness, allowing individuals to see connections between seemingly disparate elements of the world and use them to create new forms of understanding and knowledge. The contrast between the iconic representations of the engineer and the bricoleur highlights different discourses, values, and mindsets that shape emerging types, demonstrating how the two concepts play distinct roles in society.

The rise of Westernized societies has been instrumental in amplifying the significance of engineering, which is rooted in the belief that dependable and valuable work can be achieved by adhering strictly to obedience. This has given rise to the idea of an achievable societal hero who can push the limits of what is achievable. As a result, ideological concepts such as American Exceptionalism and Manifest Destiny have emerged, imposing rationalization, science, and Christianity on those who were subjugated, in order to advance the ordained by interweaving technology, engineering, and religion (Jones, 2013). Consequently, the importance of

[46] Mary Douglas (1999) views mysticism as a form of symbolic action that creates meaning and order in societies, while Michel Foucault (1977) sees mysticism as a form of power-knowledge relation. Regarding materiality, the engineer standardizes and hones objects to create new technologies, while the bricoleur works with what is provided culturally or naturally. The engineer looks towards the future, guided by scientific rationality, while the bricoleur's work centers on the tangibility of the past.

engineering in Westernized societies has not only impacted our perceptions of labor and heroism but has also had a substantial impact on shaping broader cultural and political ideologies that go beyond the confines of the field.

Engineering practices have played a vital role in creating historical assemblages of truths that differ across time and space, offering a way of controlling natural phenomena. Engineers and those who adopt engineering methods generate solutions to problems of both the material and non-material world, using tools of measurement, statistical analysis, and new sciences. Methods rooted in engineering mechanics, such as causality, efficiency, and assessment, became transferrable to other disciplines and normalized over time (Sismondo, 2004). While the emergence of a Westernized society has led to the growing importance of engineering, criticisms of causation argue that the concept is inherently deterministic and does not allow for free will or agency.

The application of engineering techniques in bridging mountain passes led to their wider application in bridging the divide between the irrational and the rational, thus playing a significant role in shaping and defining both the material and non-material worlds. Nonetheless, while engineering methods have proven to be useful, there have been criticisms regarding the concept of causation, which is a central tenet of engineering. These criticisms involve issues such as the problem of induction, circularity, hidden variables, spurious correlation, and determinism. They argue that the concept of causation is inherently deterministic and does not allow for free will or agency (Woodward, 2015). These criticisms have sparked ongoing debates and discussions within the field of engineering, prompting researchers to explore new avenues and ideas that reconcile the deterministic nature of causation with the concept of free will and agency.

The current role of engineers encompasses the ability to exert their influence over natural phenomena. However, it is essential to acknowledge the limitations of such control. The notion of service to humanity has always been at the heart of engineering practice. Florman's (1994) work, The Existential Pleasures of Engineering, compiles definitions and frameworks of engineering that underscore this connection to improve the well-being of humankind. Tredgold's (1828) definition describes engineering as "the art of directing the great sources of power in nature for the use and convenience of man" (Thorne, 2016, p. 19), a view that has been echoed by subsequent definitions. Stott (1907) posits that engineering is for the benefit of the human race, while Lindsay (1920) describes it as for the general benefit of mankind. Similarly, Hellmund (1929) contends that engineering is for the good of humanity, and Bush (1939) describes it as applying to the needs of humankind. These definitions all convey the same idea of engineering as a practice that serves the betterment of humanity.

The connection between engineering and the benefit of humankind remains prevalent in society, often evoking pride, progressivism, and an air of sophistication concerning understanding and supremacy. Engineering is embedded in disciplinary regimes that rely on demystification and infiltration methodologies, creating truths about science and complex systems. These truths hold power over individuals within a society, as they enable the assessment, reconfiguration, and sorting of people and groups based on entities such as standards and quantifications.

Additionally, these properties and methods have become deeply ingrained in modern mythology and are a fundamental part of the engineer's character, hidden beneath their austere and objective exterior (Florman, 1994). The accumulation of these intangible elements contributes to the myth of the rational engineer and the inferior bricoleur. Levi-Strauss's work contrasts the "rational and progressive" engineer with the mystical and traditional bricoleur. This analysis explores how the engineer is portrayed as the opposite of the bricoleur, obscuring alternative perspectives on engineering in the present. The comparison underscores the contrast between what is considered progressive and technologically advanced versus spiritual practices that defy explanation, despite attempts to undermine them with limited and often arrogant views that require scientific, technological, and engineering structures. Note that there are places where the term bricoleur, the production of the entity called bricolage, has been commandeered as progressive or avant-garde thought.

Bricolage, a French term referring to a form of creation involving do-it-yourself methods or simple production techniques, has gained interest across various fields. It is associated with nascent creators or "world makers" and their practices in modern science, technology, and engineering. Levi-Strauss suggests that certain constructions are not grounded in what we can perceive but rather through a hindsight gaze upon the invisible, magical, or complex. This approach defines such things rationally based on the outcomes which reflect particular desires. Bricolage has been explored in various disciplines, including anthropology, sociological ethnography, political science, women's studies, interpersonal relationships, complex information systems design, legal studies, education, evolutionary genetics, biology, and economics. A review of the literature by Baker & Nelson (2005) identified three common themes across disciplines: a bricolage perspective on democratizing innovation, the use of bricolage in maker spaces and art, and the use of bricolage in architecture.

To conclude, the relationship between power, authority, and governance is complex and multifaceted, influenced by various factors such as mythology and rationality. Mythology can be used to reinforce certain forms of governance by creating a collective identity and a shared sense of purpose. Conversely, rationality shapes scientific thought and creates systems of explanatory power, predictive power, and objectivity. The tension between science, non-science, and governmentality highlights the complex relationship between creativity, adaptability, and social control in shaping our understanding and interaction with the world. The concept of the bricoleur can provide insights into how power and authority are constructed and maintained and offer a way to compare and contrast with the modern engineer. By understanding these concepts, we can gain a deeper appreciation of the dynamic nature of governmentality and the ways in which it shapes beliefs, values, and behaviors in society.

3.2 Social Apperception in Science and Technology: An Examination of Levi-Strauss' Concept and its Implications for Engineering Choices

Integrating science and technology into different aspects of our lives can simplify complex phenomena and make them more accessible. This approach is known as "social apperception," which involves making assumptions and generalizations about social and cultural practices based on observations made through a particular lens. Claude Levi-Strauss, a French anthropologist, introduced the basis for this concept and believed that it was influenced by the rationalization and objectivity gained through the influence of science and technology. However, this approach runs the risk of oversimplification and reductionism, overlooking the complexities of social and political systems. Therefore, critically examining the assumptions and biases underlying this approach is crucial. This article explores the implications of the scientific approach and Levi-Strauss's conception of the bricoleur, which challenges Westernized epistemologies and offers a unique way of thinking that warrants further exploration.

Nolan (2021) discusses Levi-Strauss's ideas on integrating science and technology into different aspects of our lives, including the concept of "social apperception." According to Nolan, this concept refers to the process of making assumptions and generalizations about gestures, processes, and values based on observations. Nolan posits that "social apperception" enables Levi-Strauss to link effects to causes through the lens of rationalization and perceived objectivity obtained from science and technology. However, using this approach has the potential to oversimplify and overlook the complexities of social and political systems, posing risks associated with its use. Examining the assumptions and biases underlying the technoscientific mode of thinking is critical. It is essential to explore the potential consequences of engineering choices influenced by science and technology, limitations of control, and using Levi-Strauss's conception of the bricoleur as a unique way of thinking.

Latour's (1987) description of the technoscientific style incorporates both science and technology, emphasizing their intertwined and co-produced nature through interactions. This approach acknowledges the complex process of co-construction between scientists and engineers, demystifying scientific discoveries and technological innovations. Such systems infiltrate and advance particular truths, standards, and methods in various fields, including sociology and psychology. The implications of the technoscientific approach are significant, particularly in the context of engineering choices. While this approach seeks to demystify complex phenomena and make them more accessible, it also risks oversimplification and reductionism, overlooking the complexities of social and political systems. Therefore, a critical examination of the assumptions and biases underlying the technoscientific approach is necessary to ensure that the benefits of science and technology are harnessed while minimizing the risks associated with their use.

The notion of the bricoleur challenges scientific rationality and introduces a way of thinking that warrants further exploration. However, Nolan (2021) notes that throughout his work, Levi-Strauss operates from a privileged Westernized social mindset (de Certeau, 1984) and “social apperception.” Through the Levi-Strauss lens, the concept of the bricoleur challenges Westernized epistemologies. Moreover, Levi-Strauss's relegation of the work of the bricoleur to a material metaphor for folklore and mysticism [47]constructs specific truths and modes of knowledge that could be ridiculed or disregarded by Westernized epistemologies, as argued by Stengers (2018). While Levi-Strauss’s perspective does offer a valuable alternative way of thinking, it can also become caught in its effect of uncritical acceptance and retrofitting means to fit specific outcomes. Therefore, it is essential to call attention to the infiltration of technologies, the obscuring bias based on assumptions and misunderstanding, and to question rational means of being, including ideas of quantification, efficiency, and precision. Doing so exposes the

[47] Levi-Strauss characterized the practice of bricolage as a type of folk knowledge or mystical practice. In other words, he saw bricolage as a kind of "making do" with whatever materials were at hand, much like the way that folk artists or mystics might work with everyday objects or symbols to create meaning or ritual. By characterizing bricolage in this way, Levi-Strauss may have overlooked its potential as a subversive or creative practice and instead reduced it to a type of primitive or superstitious activity.

influences of power entwined in science, technology, and engineering (Haraway, 1991), which can help un-black-box complexity and ensure that the unexplained can exist.

Critics have pointed out several problematic aspects of Levi-Strauss's portrayal of the bricoleur. One criticism is that it presents an idealized view of the figure, ignoring the inequality within which bricoleurs operate. Additionally, the association of bricolage with traditionally feminine traits reinforces gender stereotypes. Another critique is that the portrayal of the bricoleur as a reactive figure lacks agency and overlooks the potential for bricolage to subvert dominant power structures. Scholars such as Derrida, de Certeau, and Lyotard have highlighted these limitations in Levi-Strauss's representation.

Derrida (1970) argued that the figure is not a non-discursive or unreflective entity, but rather that the complex interplay of language, meaning, and power shapes the practice of bricolage. De Certeau (1984) criticized the portrayal for failing to recognize the potential of bricolage as a means of challenging power structures. Lyotard (1987) also criticized the account for ignoring the role of creativity and contingency in cultural production. Despite Levi-Strauss's attempts to provide agency to the bricoleur, some scholars feel such efforts fall short. Nolan (2021) argues that Levi-Strauss's portrayal of the bricoleur can be seen as a product of a programmed producer in the form of a cybernetic pattern controlled by inferior cognitive thought and mechanized ways of reasoning. Lanzara (1999) further adds that the titles of engineer and bricoleur are unstable, with both constantly moving along a continuum that uses teleological separation to define progress.

3.3 Exploring the Relationship Between the Bricoleur and the Modern Engineer

Levi-Strauss's (1962) depiction of the bricoleur serves as a material metaphor for folklore and mysticism, connecting the bricoleur to mythology, magic, and serendipity. This ontological and epistemological point of interest forms the basis for patterns of knowing and categorizing. However, from a Westernized perspective, the bricoleur is often viewed as primitive, resourceful, culture-minded, and cunning in utilizing a non-standardized variety of materials and tools to be productive. Levi-Strauss emphasizes that just as mythology represents an intellectual "bricolage," the work of the bricoleur can create particular truths and ways of knowing through the material world and the entities they produce. However, Westernized societies tend to misunderstand or utilize a "social apperception" when exposed to such epistemologies and exhibit little scrutiny for the machinations of achieving outcomes-based designs. This way of knowing and designing can lead to complacency in creating, trusting, and making sense of science and technology beyond the grasp of the average or even semi-expert in a particular field. Westernized epistemologies tend to seek expertise and accumulated knowledge/power structures, resulting in arguments dismissive of mystical thought only if rooted in foolproof technology. Creativity, faith, and cognition lie outside the mystical and unexplainable, as long as some scientific or technical accountability exists. The search for goal-oriented outputs from existing systems has the potential to become a basis for ad hoc rationalizations, and outcomes that confirm a desired result may be problematic in some cases.

The bricoleur is an unstable entity, not only in the confines of Levi-Strauss's portrayal but also in the ways the bricoleur and bricolage have been up taken and utilized to describe particular people, methods, and creations. These descriptions counter and fortify specific normalized ways

of being and of being thought about when we consider the modern engineer and the engineering process. This correlation between the two entities and their function provides a method of contemplating how the modern engineer exists and does not exist, what is and is not engineering, and what kinds of assemblages guide science, technology, and engineering in the modern day. One can better understand the modern engineer by knowing the bricoleur and bricolage.
By drawing distinctions between the bricoleur and the engineer, Levi-Strauss suggests that both are similar entities but seems to shy away from completely reinventing the bricoleur as a precursor to the engineer.

Bringing the bricoleur into focus to recognize a different form of engineering allows for an understanding of what the bricoleur is and what the engineer is not. This difference may be noticed in the wide-ranging ways the bricoleur is considered. For instance, Johnson (2012) argues, "The bricoleur has no precise equivalent in English. He is often seen as the taker of odd jobs, one who works with his hands (handyman), uses 'odds and ends'. . . One can see here that there is an ideology of bricolage, and . . . its intellectual kinship with Heidegger's depiction of manual labor in Being and Time and his other writings on technology" (p. 361). Johnson (2012) uses Heidegger's notion of manual labor to suggest a differentiation between the bricoleur and the engineer based on ways of seeing work and production as a technoscientific advancement for a unified advancing state or as a weak sentimentality where culture and faith bond materials and within structures in ways that reflect a more "savage" way of thinking. In contrast to the engineer, the bricoleur has a different approach to problem-solving that involves working with what is considered "good enough" instead of striving for perfection (Johnson, 2012). According to Johnson, the bricoleur operates within the limitations of their specific material universe and prefers to remain within it, resulting in work that is often temporary and unstable, unlike the engineer's emphasis on permanence.

Compared to the engineer, the bricoleur relies on a set of rules located outside of a Westernized rationality or commitment to scientific reasoning (Johnson, 2012). This approach can appear to lack a logical methodology, relying instead on fate and serendipity for successful outcomes. Additionally, the bricoleur's reliance on cultural influences, rituals, and faith in what might be viewed as spiritual or divine interventions might suggest a need for more sophistication or progression one would associate with the engineer and engineering practices.

It is important to acknowledge the role of chance and unexpected findings in scientific and technological progress. According to Meyers (2007), such discoveries would be meaningless without the imaginative and innovative minds that know how to utilize them. While scientific and medical advances may not always be stumbled upon, Jasanoff (2019) notes numerous serendipitous discoveries in modern science, such as Kari Mullis's hallucinogen-induced inspiration for the concept of DNA and Polymerase Chain Reaction (PCR) (p. 50). However, this example, despite being celebrated, is still subject to scrutiny and exemplifies the heroic narrative often found in science.

Despite the basis of modern science in serendipity, irrational explanations are often marginalized in favor of progressive scientific frame changes. This marginalization highlights the positioning of the bricoleur in a less modern existence. In this context, the bricoleur's reliance on cultural influences, rituals, and faith in what might be viewed as spiritual or divine interventions might be considered less sophisticated or less rational. However, it is vital to recognize the value of the bricoleur's approach and his potential to drive innovation and progress in various fields.

3.4 The Marginalization of the Bricoleur in the Westernized Construct of Nature and the Idealization of the Engineer

The dichotomies of the bricoleur and the engineer in the Westernized view of progress and knowledge production have subtle racist constructions that highlight the engineer as the embodiment of progressiveness, practical knowledge, and discipline, while the bricoleur is associated with unruliness, deviousness, backwardness, and irrationality (Nolan, 2021). These characterizations affect society's discourse on diversity and inclusivity in knowledge production. The bricoleur works in harmony with unmitigated phenomena, positioning nature as a separate entity that is not part of man's dominion. In contrast, the modern engineer is characterized by practical knowledge, progressiveness, and being mostly unbound by history, ritual, and materials. However, these differences between the bricoleur and the engineer involve inner beliefs and intentions shared within their respective communities. Understanding these nuances is essential for promoting diversity and inclusivity in society's discourse on knowledge production.

The formation of dichotomies that suggest a basic or advanced life, typical or troubled, and exceptional or emerging can be observed through a specific lens. However, these ways of thinking have given rise to subtle racist constructions (Nolan, 2021). Such constructions are evident in the characterization of the bricoleur, which suggests propensities for unruliness, deviousness, backwardness, and irrationality, among others. This characterization contrasts sharply with that of the engineer, who is often romanticized as a hero of novels and short stories in the late 19th and early 20th centuries (Florman, 1994). Florman (1994) describes the engineer as a fair-minded and disciplined professional whose citizenship is central to Westernized notions of progressive pursuits. The engineer's methodology is characterized by proper planning, modeling, and designing.

According to Kincheloe (2011), the bricoleur becomes the embodiment of a mythological-based ontology and epistemology, providing a counter to modern scientific and engineering ways of thinking. For the bricoleur, theory is not an explanation of nature but more an explanation of our relation to nature (Kincheloe, 2011). Johnson (2012) expands on this idea, stating that the metaphor of bricolage allows us to understand better the distinction between Westernized scientific knowledge and the 'science of the concrete.' However, the work of the bricoleur in its many forms is often marginalized or invisible, while the engineer has attained an idealized position in society today (Johnson, 2012; Lanzara, 1999). The bricoleur's work is often appropriated as new creative forms, such as in art, architecture, business, and computer systems (Nolan, 2021).

The characterization of the engineer and the bricoleur is a critical topic that has implications for society's understanding of progress and knowledge production. However, while the engineer's disciplined approach is celebrated, the bricoleur's work is often relegated to the margins. Understanding the nuances of these characterizations is essential for promoting diversity and inclusivity in our society's discourse on knowledge production.

3.5 The Notions of the Engineer and Bricoleur in the Context of Materialism and Mechanics

In the Westernized construct of nature, there is a default position that views nature as an entity existing only in the eyes of human observation and the need for understanding, control, or destruction (Kincheloe, 2011). Bricolage, as an epistemology, offers an alternative approach to understanding the world and how we can consider nature and relationships in and among what is natural in different understandings and ontologies (Kincheloe, 2011). Furthermore, bricolage emphasizes alternative ways of thinking, which are further removed from what is often surreptitious to Westernized man, as the more progressive and suitable way to consider science and engineering.

On the other hand, the modern engineer is characterized by practical knowledge, progressiveness, and being unbound by history, ritual, and materials. The modern engineer embodies a culture created unto the position of engineering itself, based on ideas such as best practices, standardized tools and materials, and limits of science and technology. When designing a project, the modern engineer aligns it with best practices connected to efficiency, purity, and stability (Mambrol, 2016). Modern technologies, such as blueprints, made-to-order materials and bindings, and tools, are used to make the engineer's interactions with the materials easy (Mambrol, 2016).

The differences between the bricoleur and the engineer are rooted in their inner beliefs and communities. Lévi-Strauss distinguishes the engineer as one who strives to surpass the constraints of their civilization, while the bricoleur remains within them out of necessity or inclination (Kalb, 2017). The engineer's approach to problem-solving is based on modeling and presenting phenomena, creating a technocratic culture that emphasizes progress, rationality, and often pretentiousness. However, it is important to note that this methodology can obscure problems or shortcomings. Despite these differences, both the engineer and the bricoleur have unique strengths and limitations that contribute to their respective fields. The assurances of predictability and sometimes flawed human studies helped create followers and non-followers of progress, where the former is considered successful due to their forward thinking and rationality. At the same time, the latter are unsuccessful based on backwardness, ignorance, superstition, corruption, and laziness (Mambrol, 2016). While the modern engineer embodies practical knowledge and progressiveness and is unbound by history, ritual, and materials, the bricoleur works in particular harmony with unmitigated phenomena, positioning nature as a separate entity that is not a part of man's dominion.

3.6 The Continuum of Engineering and Bricolage: Exploring the Relationship Between Abstract Thinking and Concrete Knowing

The concept of the bricoleur and the engineer has been rooted in essential materialism and mechanics, where both are expected to create with practicality and the "public good" in mind (Levi-Strauss, 1962). However, Levi-Strauss indicates that the perception of the engineer as a more advanced designer and creator is based on racialized ideas of development and evolution. This perspective has been influenced by Ernst Haeckel's Recapitulation Theory, which draws parallels between embryonic development and the evolution of an organism. This theory has been used to create hierarchies based on characteristics and interactions that are considered more "evolved" than others, although it has since been discredited. Despite this, remnants of this theory are often used to justify colonization, salvation, and prophetic concerns (Gould, 1977). The bricoleur has been viewed as an embodiment of earlier stages of cultural development. According to this view, the bricoleur represents a more primitive, pre-scientific mode of problem-solving, in contrast to the modern, scientific approach of the engineer. From this perspective, the bricoleur is seen as an example of how earlier stages of cultural development are "recapitulated" in individual human development. In the racialized view, the bricoleur existed earlier on the spectrum as particular rationalities, needs, and desires drove the engineer toward other means (Da Silva, 2005).

Engineers create to solve problems, moving away from a culturally centered process to an outcomes-based process, finding localized and immediate needs, efficiency, and the like. They also moved forth on developing a set of criteria, practices, and standards. The bricoleur's organization systems differ from the engineer's pure scientific reasoning. S/he brings organization to the "sensitive world" by accounting for materials and their place in their particular culture. This categorization practice places all things under the guise of a universal order created not by man but within a world creation system (Da Silva, 2005).

However, Johnson (2012) states that Levi-Strauss's Bricoleur is indiscriminating to materials, noticing the science, art, and magic within each object or system and how it might be helpful with other objects and in other systems. This process runs counter to a trajectory of tangible, standardized, and industrialized means shaped by constant technoscientific pursuits based on formulations of new truths, desires to expand and hone (compartmentalize, make self-evident) systems, and analysis based not on connections and histories of the means but with an uncritical focus of outcomes and progress.

Engineering is often seen as a stable and reliable endeavor compared to the more fluid approach of bricolage (Gray, 2015). Engineers tend to focus on creating permanent structures. At the same time, bricoleurs emphasize culture, society, and rituals more, understanding that creations will inevitably become part of other creations and that immortality lies in contributing to individual parts rather than the complete composition (Mambrol, 2016). Derrida's (1967) work is particularly relevant to the Westernized understanding of engineering production and structures, as he suggests that such systems are inherently unstable. That deconstruction can uncover their contradictions and instabilities (Mambrol, 2016).

The relationship between engineering and bricolage can be seen as a continuum rather than a polar opposition. The former represents a more abstract and logical approach to systems, methods, and materials (Kincheloe, 1999). Derrida's (1967) concept of the plane of ontology and epistemology is useful in understanding how the bricoleur would conceptualize the engineer as a mythological figure working within the confines of the natural world (Derrida in Kincheloe, 2011). However, the influence of the Modern engineer as hero (From Chapter 2) has allowed Westernized societies to view engineering as a form of salvation from nature's "cruelty," leading to potential problems when technological progress is pursued without addressing root inequities. The distinction between the bricoleur and the modern engineer encompasses a spectrum of proficiencies in scientific solutions, stable societies, and the boundaries of the material and non-material while emphasizing the autonomy and reverence of the engineer and the marginalization of the bricoleur (Mambrol, 2016). It is noteworthy to consider the relative stabilities of social structures and the role of materials in the world concerning subjectivity and the construction of individuals since social structures do not determine individual subjectivity but constrain it in intricate ways (Kincheloe, 2011).

To understand the shaping of subjectivity, the bricoleur employs a range of strategies, according to Markham (2017). This approach acknowledges the influence of various factors in the meaning-making and production processes, which are closer to culturally fixed rather than socially connected default states of being. Markham (2017) suggests that "Tinkering, in the Levi-Straussian sense, then, is not just about using whatever is at hand, but involves a critically oriented, multiperspectival, and reflexive cognition (p. 49)." Bricolage methods may appear crude and primitive when viewed through a modern lens, but it is crucial to examine their role in shaping the ways in which science, technology, and engineering have influenced and solidified Westernized and non-Westernized approaches to interacting with and observing phenomena, as well as shaping truths, disciplines, and aspirations for controlling future events.

Bricolage is considered a more concrete way of knowing, obscured in plain sight or "taken for granted" (Markham, 2017). This way of knowing implies that engineers are more abstract thinkers who contemplate the idea of "what can be" instead of what is. Portraying engineers in this manner enables the creation of thoughtful, rational, and trustworthy individuals in contrast to the modern "savage," who is usually impulsive, irrational, and deceitful. However, it is essential to note that these distinctions between the bricoleur and the engineer are not fixed or absolute. Instead, they are contingent and changing, depending on historical, cultural, and social contexts

(Kincheloe, 2011). Additionally, both the bricoleur and the engineer can be seen as valuable contributors to society and culture since they provide different approaches and perspectives on solving problems. Finally, the space between the bricoleur and the engineer represents a dynamic and complex field of inquiry that encourages us to question our assumptions about knowledge, creativity, and innovation and engage in ongoing discussions about the role of science, technology, and society in shaping lives and futures.

3.7 Exploring the Concept of Apperception in Engineering and Social Science

In this chapter, the concept of "social apperception" was introduced to explain how Levi-Strauss's ideas may have reflected biased thinking as a result of historicism (Nolan, 2021). In this context, the term apperception is used to illustrate how engineers can create a reality that is supported by rational technoscientific progressivism. According to Ulich (1967), apperception refers to the mental process that raises subconscious or indistinct impressions to the level of attention and organizes them into a coherent intellectual order. However, this definition can be misconstrued as mere consciousness. To address this ambiguity, I propose a hybrid meaning of apperception that considers past experiences over present ones, knowing over doing, planning over improvising, rationality over ritual, and demystification over spirituality.

Leibniz (2018) distinguishes between perception, which is an inner state of the monad reflecting the outer world, and apperception, which is our conscious reflection of the inner state of the monad. This perspective highlights the modern elucidations that arise from planning and predicting the future. Madhavan (2015) notes that the modern engineer's approach is tied to outcomes, utilizing a set of methods and standards that have been successful in previous situations, and knowing what one wants. The pursuit of the perfection of the final product through theorizing and changing the production line is the solution. This idea is particularly evident when comparing the engineer to the bricoleur. McDonald (2018) states, "Scientific thought is represented by the engineer, a master of efficiency who determines beforehand what tools are needed for a job. Mythic thought, by contrast, is represented by the quixotic figure of the bricoleur, who is an expert at recombining what lies ready to hand. One is a master of ends, the other of means" (p. 109). However, the power involved in being the master of ends over means takes on a different context when applied to what is possible through the reapplication of ends in order to redefine the means. In other words, when one collects the reflections in the form of information and data and reapplies them employing the STE assemblage, the means become a prescribed way to meet goals or make the "ends" appear.

The concept of making the invisible visible to justify ends rather than means is an intriguing phenomenon. This idea suggests that the use of effects, such as data or evidences, to name and "see" causes can formulate solutions to the "just existing" problems (Harman, 2018). In the early 20^{th} century, progressives aimed to make material things in the world more efficient and precise, but those seeking scientific solutions to perceived social and household problems saw opportunities to name and reverse engineer the causes of perceived "abnormalities" (Harman, 2018). This phenomenon was especially noticeable in the social sciences, where psychology exhibited a tendency toward apperception and the desire to will particular truths into existence (Kantor, 1963).

As engineering, science, and technology became more intertwined with society, assertions gradually extended from material to non-material solutions for societal issues. These claims seeped into both the physical and mental realms disguised as static connections identified by the principles of science and technology, and categorized and clarified by the norms of scientific and engineering practices. Engineering offered possibilities for scientific salvation through technology, tools, graphs, and definitions, while assemblages related to aspects of design, standardization, efficiency, miracle-working, prophecy, production, and discipline became natural entities of the body and mind (Cisney & Morar, 2016). Consequently, the analysis of scientific salvation relied on quantifications related to all of these aspects. Quantifications facilitated straightforward judgments, comparisons, and categorizations of elements that seemed necessary to judge, compare, and categorize, thus providing power not only in actions but also in the perceived necessity of those actions.

Efficiency and precision standards were crucial to the new metrics of scientific, societal, and engineering control. Technoscientific progress relied on promises of efficiency and precision based on the assessment of number patterns. Quantifications, as entities, lend science a noticeable authority level in many aspects of modern life. In engineering, these numbers help establish standards and limits in applications to materials to make them more precise, efficient, and interchangeable (Gooday, 1990). With this authority and accuracy, measurement, assessment, and surveillance based on reformation became a socially progressive and ethical positive (Schaffer, 1992). This condition paved the way for the utopian dreams of progressives through social engineering (Leonard, 2016).

However, while many supported these ideals, there was some resistance based on individual agency and questions of equity. Croly (1914) noted utopian imaginings of a "better future [that] would derive from the beneficent activities of expert social engineers who would bring to the service of social ideals all the technical resources which research could discover, and ingenuity could devise" (p. 3). Croly (1924) questioned the application of social engineering, exposing the idea that engineering of this type often arises from a specific point of view that may or may not lie within the fundamental interests of subjects. Leonard (2016) noted that without political participation, the social engineer existed as an undemocratic entity that became a "traditional law-giver who knew what was possible and good for other people and who proposed to mold them according to his ideas (p. 188)."

The possibility for discipline and normalization enabled the diffusion of power from a central entity into and through individuals under the guise of collective progress, autonomy, and efficiency. These possibilities created particular narratives and systems utilizing engineering methods and ideas of standardization, where expertise, trust, and self-discipline were essential—for example, measuring and assessing particular behaviors of "the mad" results in specific punishments and degradations administered passively and neutrally. These actions acted on the body in two ways: First, it made clear that through some measure, certain behaviors were not normal. And second, punishment should be internalized to blame the self (Rose, 1985).

3.8 Expertise, Control, and Power

In terms of defining expertise, Germain's (2006) Generalized Expertise Measure[48] is a psychometric measure of perception of employee expertise that includes objective and subjective

[48] Germain's Generalized Expertise Measure is designed to measure an individual's cognitive ability to quickly acquire knowledge and skills across different domains, rather than measuring expertise in a specific area. The measure is typically used in research settings to investigate the relationship between expertise and other variables, such as problem-solving ability, decision-making, and creativity..

items. Objective items relate to evidence-based expertise, while subjective items relate to self-enhancement behavior, such as ambition, the ability to assess importance in work-related situations, and self-improvement capability. Germain (2006) also added a behavioral dimension to the definition of expertise beyond the dimensions proposed by Swanson and Holton (2001). While Germain's Generalized Expertise Measure provides a useful framework for understanding the dimensions of expertise, it is essential to consider the broader social and cultural context in which expertise is constructed and applied. This is particularly relevant in complex power dynamics and the regulation of bodies and behaviors. For example, Cisney & Morar (2016) highlight the ways in which biopower is characterized by forms of control over bodies and time, which have a significant impact on individual and societal norms. Understanding this dynamic is crucial for developing a nuanced understanding of expertise and its role in shaping contemporary society.

Cisney & Morar (2016) argue that biopower shares similar characteristics in terms of control over bodies, as well as space and time. This control includes disciplinary actions such as defining a standard way of being and scheduling time and place for specific activities within a structured day (Prakash & Hart, 1999). According to Prakash & Hart (1999), this form of control is exemplified by a French police officer in 1749, who stated that public order could be achieved through strict regulation of transit, schedules, alignments, and signal systems, as well as environmental standardization that makes the entire city transparent to the policeman's eye (Guillaute, as quoted in Virilio, 1986, p. 18).

Stoler's (2010) analysis of discipline in the British colonies and asylum workers revealed that disciplinary technologies focused on concentrated control over individuals and groups, employing a rational and reasoned management system that created, distributed, and managed the "system" through particular forms of expertise and layers of workers. This system limited existence to forms and measurements that aligned with desired outcomes. The power of governance was embedded within the system, utilizing power, neutrality, and expertise to control. Experts in a technoscientific society consistently impose power utilizing moral and technical know-how, with expertise shifting from philanthropy to science and scientized pursuits such as economics, statistics, sociology, biology, and psychology (Barry et al.., 2013). The rise of expert figures, such as the scientist, engineer, civil servant, and bureaucrat, is evident from the late 19th and early 20th centuries. New techniques for ethical formation and capacitation of individuals who would exercise authority, along with a range of scientific and technical knowledge, allowed the possibility of exercising rule over time and space (Barry et al.., 2013).

Social scientists are often responsible for creating cognitive models that result in the systematization of individual differences, ultimately influencing power differentials in society. For instance, in a study by Chi et al. (1981), experts and novices in physics problems differed in their categorization and representation of problems. Novices tended to categorize problems based on surface features, while experts categorized problems based on deep structures or underlying physics principles. Experts had schemas containing more procedural knowledge than novices, which aided in determining which principle to apply. In contrast, novices' schemas mostly contained declarative knowledge that did not aid in determining problem-solving. This conception reveals a systematization attributed to social scientists who create individual differences through various cognitive models, ultimately influencing societal power differentials. Barry et al. (2013) point to the power of psychology in transforming judgments from "spheres of values, prejudices, and rules of thumb" to "spheres of human truth, standards, justifiable choices, and objective criteria." These latter "spheres" represent progressive interests that impact the expert's authority. Rose (1992) states, "Psychological expertise renders human differences technical. Its capacity to render the person objectively calculable, to differentiate according to nature and not according to prejudice, has made possible and justifiable the spread of the psychological 'techne' of calculation" (p. 359). The invisible is made visible through numbers, creating number formations that become a matter of differentiation. These differences do not exist in the physical structures of the body but in ethereal "spheres" or places of discipline. Such differences are made to exist in the non-material body or, as Hook (2007) states are located within the soul.

3.9 Exploring the Relationship Between Bricoleurs, Engineers, and the Scientization of Modern Westernized Science

According to Levi-Strauss (1962), the savage's concrete images and concepts, as exemplified by the bricoleur, were foundational to mythological thinking and were prioritized over scientific thought. Nolan (2021) suggests that the engineer's ability to think in abstractions set them apart and made them essential to technoscientific progression in modern Westernized science. Viveiros de Castro (2019) argues that the bricoleur's focus on the "science of the concrete" creates a primitive ordering of nature, where explanations of relationships and systems are "good enough" as they exist without the need for further investigation.

Hawkes & Hawkes (1977) note that the outside view of bricolage suggests the work of an illiterate and non-technical "primitive" mind, lacking in logical patterns, orderings, and classifications. However, they argue that through concrete approaches, the bricoleur's "ulti-conscious" mind uses creations connected with the world in many different and bewildering ways far removed from Westernized consciousness. This approach suggests a way of thinking that holds steady to the known and material instead of reverse engineering solutions and touting their transportability across multiple applications.

Kantor (1963) argues that social trust in technologies is based on the precision of quantification, efficiency, and promises. The use of numbers creates power through evidence and accuracy, which are universalized and relied upon. This emphasis on quantification has had a profound impact on the scientization of many disciplines, including psychology, which has developed engineering practices and designs aimed at intangible concepts such as the human mind, behavior, and soul. While the engineer is created through reverse engineering and the bricoleur through engineering, this study focuses on the scientized methods used, including measurements, observations, and assumptions, and the pseudo-prophetic notion of a righteous teleological conception (Nolan, 2021).

This teleological conception creates a paradigm that feeds its own goals, leaving us to question how the marginalization of the bricoleur in Westernized society has affected the creation of engineers and what counts as engineering. The engineer's combination of science, technology, and engineering drives a loop between scientific discovery and engineering prowess that relies on precise quantifications and promises, creating a culture of trust in these methods. This culture of trust has had a profound impact on the development of psychology as an engineering discipline, with a focus on measurements, observations, and assumptions, which have been universalized and relied upon. In essence, the focus on quantification in engineering has led to the scientization of many disciplines. It has created a culture of trust in methods that resemble those of the engineer. The marginalization of the bricoleur in Westernized society has raised questions about the creation of engineers and what counts as engineering (Nolan, 2021).

3.10 The Power and Authority of Psychology in Normalizing and Categorizing Behavior

Psychology has gained authority through its close association with medical and applied scientific methods and values, as well as the circulation of its ideas and discourses within society. With its established sense of rationality and progress, science can lend credibility to other entities as long as they make sense of the world and are comparable (Rose, 1993). The authority of science and the function of engineering intertwine with the realm of psychology, as Rose (1993) argues, where psychological ideas are seen as intellectual technologies that allow for the application of thought in and to the world in specific ways. The entanglement of ways of seeing and acting with specific practices of experimentation, investigation, and interrogation arises in academic settings and various social locales.

As a scientized discipline, psychology applies particular methods of normalizing and categorizing, becoming both a discipline and disciplining entity. Psychologists establish rules and standards for organizing the mind and defining normal behaviors through observation, diagnosis, and classification, utilizing case studies and confessional technologies such as interviews and personal histories to establish abnormalities (and normalities) (Rose, 1993).

The formation of psychology and its designs to build from collections of data are normalized in Westernized society. Psychologists utilize societal inputs and reactions to collected information, including observations, data, and diagnostics, to form power/knowledge regimes. These regimes establish the possibility for an apperceptive analysis utilizing deconstructing outcomes and reapplying them in order to create boundaries of acceptable beings and behaviors. Through comparisons of subjects to norms, disciplinary interventions, surveillance, and punishment are invoked, leading to the self-construction of subjects through the gaze of societal norms and pathologies drawn from exemplary end aspirations (Prozorov, 2021).

As a discipline, psychology attempts to change the conditions of abnormalities through interventions that focus on the individual, with success or failure assessed within its established terms (Synnott, 1993). This perspective regards conditions like madness not as entities in themselves but as manifestations of illnesses that require definition and intervention. A Westernized rational society then establishes limits on the absurdity of the "condition" while holding up a mirror to the "inflicted" as a means of self-demystification and reflection. According to Hook (2007), this leads to "further knowledge production and the raw materials of a continually expanding and continually refined system of diagnosis and categorization," with new techniques of power emerging as a result.

Synnott (1991), expanding on Foucault’s (1973) notions of madness, highlights institutions such as asylums, schools, and therapeutic arenas as laboratories of experimentation with techniques of understanding and defining means of social control. The discourse of psychology has permeated various aspects of everyday life, with psychological ways of thinking and acting moving into other areas of professionalism, including medical professionals, social workers, and management (Rose, 1993). As a result, psychology gains authority through its proximity to medical and applied scientific methods and values and how its ideas and discourses circulate through society. In this way, psychology has become a powerful tool for normalizing and categorizing behavior, and its impact is felt throughout society. Through its interventions and techniques, psychology seeks to establish rules and standards around the practice of organizing the mind and defining normal behaviors. This process of normalization and categorization has profound implications for individuals and society as a whole, as it shapes our understanding of ourselves and our relationship with the world around us.

With adherence to an underlying system and a means of circulation and confirmation of ideas, psychological ways of being, knowing, and treating have become entangled in fluctuating levels of influence. Psychological truths are generated through discourses of investigation, diagnosis, confession, and judgment (Rose, 1993). Assemblages bring together material and non-material worlds, utilizing technologies of pathologies to find and define problems, as well as technical tools, apparatuses, and tests to reveal, measure, and recalibrate such problems. The goal is to let the particular psychological framework of the time provide the basis for and normalize a perceived natural being. The aspiration is to be in the "sweet spot"; not too shy, not too loud; not too happy, not too sad; not too disorganized, not too compulsive.

However, normal and abnormal would need to be defined to use the power of normalization. Power and knowledge become interwoven so that knowledge of individuals and populations could become points of interest, concern, and places in need of salvation (Hook, 2007). As

Foucault (1975) states, a new technology of power was implemented when individuals moved from historico-ritual mechanisms for the formation of individuality to scientifico-disciplinary mechanisms. Measurement of normality became a moment when this new technology of power was implemented (Foucault, 1975). Psychological ways of being, knowing, and treating have become entangled in fluctuating levels of influence. With power and knowledge becoming interwoven, knowledge of individuals and populations has become points of interest, concern, and places in need of salvation. The measurement of normality became a moment when a new technology of power was implemented.

3.11 The Role of Quantification and Experimentation in the Scientization of Psychology

The use of quantification and measurement methods has been instrumental in refining perceived truths. This use has led to an increasing demand for advanced levels of scientization, such as experimentation (Shapin & Schaffer, 2011). The evolution of science has seen experimentation replace a science-based more on Natural Philosophy. Initially, experimentation focused on pursuits in medicine and the understanding of the physical body before expanding into biology through disciplines such as physiology. Physiologists such as Helmholtz and Johannes Miller believed that the body and soul functioned within the same framework without transcendental interferences (Kantor, 1963). However, as the explanation of the body became more complex, there was a growing demand for a psychic control and motivating power for the body's mechanisms. This point made entities of the soul, with their mystical and curious existences, objects of interest (Kantor, 1963). The adoption of quantification and measurement methods has propelled the increasing call for scientization through experimentation, replacing a science based on Natural Philosophy and becoming fundamental to modern science (Shapin & Schaffer, 2011).

The evolution from natural philosophy to science and engineering has been a gradual and intricate process spanning several centuries, according to Shapin (1994). This shift involved an increased emphasis on empirical observation and experimentation, leading to the development of new scientific disciplines and methods. The scientific revolution of the 16th and 17th centuries was critical in this transition, leading to the emergence of experimental and mathematical approaches. By the 18th century, science had become a well-established field with an increasing focus on empirical evidence and the development of testable theories. As science progressed, it became a collection of ideas, methods, and tools used to solve problems in an era of expanding trust in science. The expansion of science led to the accumulation of knowledge through the standardization of techniques, materials, methods, and actions for comfort, protection, and control.

However, the transformation of problem-solving is influenced by relations of power, influence, and differing ideas of self-preservation. These ideas and power relations define who can be problem-solvers and who cannot, what (and who) are considered problems, and who is not. Shapin's (1996) ideas are particularly relevant to understanding what is considered natural and what is made to be "natural" and the transition from natural philosophy to science and engineering. The manipulation of nature to fit human needs has led to the creation of various technologies that have transformed society. Nonetheless, these advancements have been limited by various power relations, influencing access to technology and its usage. The transition from natural philosophy to science and engineering has transformed problem-solving by defining problems, solvers, methods, and means, leading to standardization based on comfort, protection, and control. Nevertheless, this transformation has been limited by power relations, influence, and differing ideas of self-preservation.

Kantor (1963) asserts that the cultural institution of soul and body was firmly established in the seventeenth century, leading physiologists to assume a correspondence between bodily and psychic processes. Although not the intention of researchers and philosophers at the time, this assumption challenged Cartesian Dualism[49] by attempting to define the interface between body and soul. As scientists sought to scientize the soul by employing standard practices of science parallel to the study of the body, they aimed to explain the soul through modern scientific theories, methods, and experiments. However, as Kantor (1963) notes, the scientific community assumed that psychic experimentation was possible, leading to the naturalization of the soul and the attempt to overcome the uncrossable chasm between the "spiritual" and the "natural."

Kantor (1963) further argues that the re-emergence of scientific institutions as part of the massive cultural complex in Westernized Europe resulted in psychological events being treated as objects of investigation. Scholars attempted to naturalize the soul by bringing it under the rule of number and measure, experimentation, physical and biological correspondence, or other means. Rather than being based on phenomena, the formation of these truths relied on "imperative outcomes," which instilled trust in the methods of science. This resulted in the creation of engineering ideals that allowed for the consideration of the soul across multiple

[49] René Descartes proposed Cartesian dualism, a philosophy that separates the mind and body as two distinct entities. The mind, or soul, is viewed as a non-physical substance that is the source of consciousness, thoughts, and beliefs, while the body is a physical substance that is subject to the laws of nature. Cartesian dualism is still debated in various fields, including philosophy, psychology, neuroscience, and theology, as it is considered by some to be a limited and outdated way of thinking about the mind-body problem. Others argue that it still has relevance and can be integrated with more modern theories of the mind and brain.

disciplines, including biology, leading to the demystification of non-material entities such as DNA and protein synthesis systems. However, the scientization of psychology and the design of the soul have faced criticism on philosophical grounds, including the contrast between mechanization and vitalization, the objectivity of observations, and the presence of transcendent qualities, which often offer abstract concepts rather than concrete ideas.

Kantor (1963) contends that the perception of the bricoleur as merely a concrete thinker limits him to a categorization of impulsiveness, disinclination, and irrationality. On the other hand, abstract thought becomes about causality, observation, and controlled experimentation, leading to the naturalization of subjective behaviors and actions of man. Although psychological events are just as tangible and observable as the events dealt with by astronomers, physicists, chemists, and biologists, the psychological domain has historically been tightly controlled by nonscientists, with the primary interest being in man and his destiny.

The combination of nonscientist disconnection from traditional scientific expertise, the commandeering of science methods and means, and the focus on the progress of man suggest particular parallels to basic ideas of engineering. As general cultural conditions are brought into the discourse along with specialization of and within such general institutions, regimes of truths, standards, and possibilities, psychology becomes an arena for cultural clashes. Interest in mapping and understanding the workings of the individual soul seems to have become essential to progressive thought in the modern era (Kantor, 1963).

3.12 Behaviorism: A Mechanistic Approach to Psychology in the Early 20th Century

In the early 20th century, the field of psychology underwent a revolution in thinking that brought forth the application of behavior-focused methods in connection to human actions (Kantor, 1963). This shift in thinking was influenced by the recognition that psychological reasoning dealt with non-material and transcendent entities, which gave it an air of a softer form of science, especially as wartime engineering and industrial technologies began to transform scientific rationality. In addition, the interest in animal studies that followed the dissemination of evolutionary theory raised the question of why psychologists should concern themselves with sensations, consciousness, and other transcendent matters when the behavior of organisms is actually all that is being investigated. As a result, the abstraction of concrete behaviors and theorization formed around causality became a part of a psychological movement known as behaviorism (Kantor, 1963).

Behaviorism has its roots in mid-19th century Darwinism, Galton's work, and early behavioral genetics [50] (Morris, 1993). The theory of evolution's "survival of the fittest" mantra provided new rationalizations for the discrepancy between the wealthy and the abject, employing conceived genetic tendencies, which brought the understanding of the mechanisms in genetics and evolutionary theory into concerns located in social and psychological realms. Morris (1993) considers adherence to a mechanist conviction important to the job of a behavioral analyst, as

[50] Darwinism: The theory of evolution proposed by Charles Darwin, which asserts that species evolve over time through a process of natural selection. Galton's work: Sir Francis Galton was a 19th-century English scientist who made significant contributions to the fields of psychology, anthropology, and statistics. Galton was particularly interested in the concept of heredity and the ways in which traits are passed down from generation to generation. He is known for developing the idea of eugenics, which advocated for the selective breeding of individuals with desirable traits in order to improve the human population. Early behavioral genetics: The study of the genetic and environmental factors that contribute to individual differences in behavior.

behaviorism was considered a natural entity of man and foundational to psychological analysis. Behaviorists ignored the "mystical" and searched out concrete observations, ignoring transcendent processes (Kantor, 1963).

Observations of bodies, behaviors, and responses to interactions and reactions to material stimuli (experimentation), along with other scientific methodologies, became a popular way to make certain intangibles appear (Morris, 1993). Mechanism in action would become the naturalistic default and way of existing. In his book, "The Behavior of Organisms" (1938), B.F. Skinner, a prominent figure in behaviorism, argued that behavior tends to remain consistent under controlled circumstances. He viewed behavior as a mechanistic process that follows natural laws and operates within a structured system. Causality and response offer the ability to trace responses along a system where phenomena, materials, and the non-material produce behaviors.

In Beyond Freedom and Dignity (1971), Skinner moves from simile to full metaphor in his mechanization of man: "Man is not made into a machine by analyzing his behavior in mechanical terms... Man is a machine in the sense that he is a complex system behaving in lawful ways" (p. 202). To be a mechanism, as Skinner (1938) describes it, is "to be free from the intervention of any capricious agent" (p. 433). Inversely, to be a mechanism is to deny vital forces and transcendental minds and to embrace naturalism.

The concept of mechanism encompasses two fundamental aspects. According to Malone (1990), the first aspect is the belief that explanations of natural phenomena should not invoke supernatural agents such as demons or life forces. This belief is commonly known as determinism in science, as it posits that natural phenomena are governed by fixed laws and that these laws can be discovered and described through empirical observation. The second aspect, as Malone (1990) defines it, is the assumption that scientific subject matter, such as behavior, is lawful and orderly and can be accounted for. The study of bodily mechanisms provided a means of investigating unobservable phenomena, such as fear, hunger, or motivation, as these mechanisms could indicate their presence (Kantor, 1963). To this end, dogs, white mice, and guinea pigs were commonly used as models to generate data on instinctive behaviors, anticipatory manners, and complex psycho-social simulations. These models were regarded as indications of scientific standards and expertise, allowing for the extrapolation of information in line with the rational scientific model (Kantor, 1963).

3.13 The Intersection of Technology and Humanity: Examining the Engineering of the Soul and Body

The progression from the bricoleur, an irrational and culturally centered individual, to the engineer who works within rational systems is analogous to the evolution from mechanical to complex computer systems. As technology integrates with human behavior, relationships between individuals and their identities become increasingly complex. The boundaries between body and soul have become blurred as they are both influenced by scientization and machination. The "psychology-effects" of the soul are dependent on the positioning of the body in space and time, which is often under surveillance or in a state of productivity, resulting in disciplinary outcomes (Hook, 2007).

One can view the engineering of the soul as a systematic approach that is implemented onto the body (tested), monitored or quantified (measured), evaluated for results (evaluated), and modified. As a power regime, this system operates on the soul to engrave a certain "knowledge" onto it, serving as an automatic, self-executing pattern or "identity," leading to a regime of self-awareness and observation where a series of physical actions and attentions are incorporated at a distinct level (Hook, 2007, p. 109). Rose (1992) called this phenomenon "Engineering the Human Soul" as a way to understand the place of these "new engineers" within the sociopolitical arrangements of liberal democratic societies. The soul is shaped and reshaped to reflect "scientific techniques and the discourses and moral claims of humanism" (Foucault, 1975, p. 30). Thus, the soul becomes redesigned as a non-material regulatory system of surveillance and morality. Or, as Foucault (1975) states, the soul becomes the prison of the body.

Both body and soul are manifestations of origins and displays of our actions and conduct. Outcomes-based solutions of defining, measuring, assessing, and sorting the non-material based on the production of an objective exemplar are vital in understanding how we are disciplined to think, act, and exist. In conjunction with the body merging with materials for the reason of discipline and power, entities that control from top-down structures are enabled to discipline from afar through and into subjects through particular systems, institutions, and truth regimes (Foucault, 1977).

3.14 Governmentality, Science, and Engineering: The Control and Transformation

Governmentality can be understood as the conduct of conduct, which describes systems of power and their reach over society and individuals. The concept of governmentality is based on the mechanics of power within a societal system, but it extends to the personal lives of subjects. Institutions such as schools, prisons, and health systems are used to regulate behaviors and beliefs of populations through subtle means, such as favoring particular morals and values and normalizing particular ways to be. The soul, whether individual or shared, becomes an entity of concern through governmentality, where interventions can become control mechanisms that have the potential to stifle or promote free will under different consequences. For example, the freedom of religion can be seen as a positive portrayal of governmentality where the government permits the expression of spiritual freedom. However, this interface between the state and the subject becomes complex when permission is required to act, potentially leading to oppressive control. The human body, mind, and soul have been the subject of various forms of science applied to the brain, thinking, and cognition and used to create technologies of governmentality. Society desires to engineer and control what is natural, leading to the development of engineering as a social science (Foucault, 1978).

According to Hickman (1990), problem-solving science in society has led to the development of discipline systems that identify and solve problems through scientific methods, rationality, and social systems. This process also involves creating certain truth objects, such as trust in engineers. The humanistic side of engineering recognizes the human influence on science and engineering, while progressive problem-solving focuses on mechanical and computer-based problem-solving.

Foucault (1980) emphasizes the sociopolitical aspects of engineering, problem-solving, and governance, with a focus on the denial of change in education and the construction of national policy and evaluation. The governmentality concept, as Rose (1999) outlined, emphasizes the relationship between power and individuals in society, particularly regarding control mechanisms, social systems, and truth objects. In addition to investigating the epistemological character of political rationalities, governmentality scholars also explore the problem-oriented nature of governmental activity. They examine how certain events, processes, or phenomena become formulated as problems and investigate the sites where these problems are given form and the various authorities accountable for vocalizing them. Dean (1999) emphasizes the importance of technical instruments in shaping the behavior and attitudes of individuals and groups. These instruments include accounting procedures, standardized tactics, pedagogic, therapeutic, and punitive techniques of reformation and cure, architectural forms, professional vocabularies, and material inscriptions such as information, data, and knowledge.

The concept of governmentality highlights the importance of knowledge and expertise in shaping governmental practice, the continuous classification of experience as problematic in the exercise of governmental authority, the role of technical instruments, and the diverse types of selves, persons, actors, agents, or identities that arise from and inform governmental activity. By understanding these dynamics, we can gain insights into how power is exercised and contested in modern societies.

3.15 The Technologization of Life: Foucault's Concept of Biopolitics and the Evolutions of Governmentality

Foucault's (2008) concept of biopolitics refers to the exertion of power on individuals and populations through scientific and technological means, affecting both their bodies and souls.

This shift in the exercise of power moves from individual disciplinary procedures to the management of entire populations, with life itself becoming subject to control and biopower emerging as power over life (Cisney & Morar, 2016). As part of post-enlightenment ideas, biopolitics, biopower, and governmentality have led to the establishment of rules and regulations that aim to regulate and normalize personal choices, striving for moral status in areas such as hygiene, health, and sexuality. This is illustrated by surveys conducted after World War II to classify families based on technical noticings, hygiene science, and designed surveys (Cisney & Morar, 2016). Biopolitics refers to how power impacts the body and soul of individuals and populations, employing scientized and engineerized forms of technologies and techniques. This power shift has led to the normalization and regulation of personal choices and the strive for exemplary status in various areas.

The evolutions of governmentality derived from new forms of science, technologies, and engineering feats have led to the generation of new knowledge and identities and the incorporation of social science models into various disciplines. Scientized methods and questions, along with standardized considerations, shifted identities from historical, cultural, and literary contexts to more scientific-centered self-awarenesses. With this new authority in methodology and standardization, social science models became part of disciplines such as law, medicine, archeology, computer science, and engineering (Savage, 2010). Models grounded in a governmental mode also provided prophetic easements and security from future happenings.

Foucault's concept of "security" refers to the structured efforts to meticulously analyze and manipulate the probabilities and statistics associated with phenomena that may harm the overall "health" of society (Cisney & Morar, 2016). This notion of "security" serves as a managing force that permeates and operates within societies through intermediation and assertion. The reduction of the individual's body and mind to a scientific and material existence for the purpose of control and salvation involves assemblages of truths, methods, and technologies that create numbers, statistics, and equations based on targeted normalizations (Cisney & Morar, 2016). These systems of normalization are based on creating the unnatural from a perceived nature and vice versa. In this context, perceived nature serves as an a priori phenomenon whose simplicity and undisturbed being allows for a sense of neutrality and purity, which, when acted upon by the STE assemblage, becomes an extension of purity under the influence of rational manipulation.

The practices of pathology and medicine serve as a clear example of this phenomenon, where pathologizing practices categorize subjects into the domain of normal and abnormal, where abnormality usually calls for a form of "corrective" intervention. These interventions are based on specific assemblages designed to embed quantifications, probabilities, and "best practices" into diagnosing problems related to disease on both personal and population levels (Foucault, 1973). Prophecy and salvation become the driving force of a secure and comfortable life, which is deemed to be an integral part of a progressive society[51]. The engineerization and technologization of the body and mind have become ways of knowing people and populations. Social, political, and individual technologies or engineerizations have evolved into ways to provide acceptable accounts of being with regard to the body and mind, employing discipline and normalization through measurements and assessment created at a distance from and brought into "natural" conditions to be once again interpreted, assessed, and categorized. However, an

[51] Recent battles surrounding vaccinations, especially mRNA vaccines such as Pfizer's and Moderna's, provide an opportunity to study how this mindset changed in the early 2020s.

intangible element exists that behaves unlike the physical body or the predictable mind, indicating a missing element of control.

Foucault's notion of "security" provides a lens through which to understand the ways in which science, technology, and engineering have transformed and manipulated the natural world to create new systems of normalization. This transformation has led to the engineering and technologization of the body and mind, resulting in new ways of knowing people and populations. These new systems of normalization create situations where the unnormal becomes unnatural, and the exemplar becomes the aspiration. However, the gap between theory and practice is significant, and there remains an intangible element that resists control.

3.16 Exploring the Complexities of Motivation

Scholars from various fields have long examined the concept of separating the mind, body, and soul. Although these elements are often viewed as distinct and independent of each other, they can work in accordance with their position on a particular view (Edwards, 2019). For instance, the idea of motivation is often considered an intangible entity within the soul. It is neither a physical manifestation nor an indication of intelligence, but rather a force that drives individuals to produce, create, and succeed. In this regard, motivation becomes a vital component of a liberal progressive Westernized world where desirable consequences are highly valued (Eisenberger, 2012).

Motivation can be considered a complex concept that requires a rational pattern of logical thought and a methodology that follows systematized patterns of thinking (Eisenberger, 2012).

As such, it is possible to make motivation into a method or mindset that can be applied to different situations, such as the workplace. By reverse engineering particular data sets of motivated individuals, it is possible to identify the drivers of motivation and create an exemplary employee who can produce positive outcomes (Deci & Ryan, 2008). However, when considering the concept of the bricoleur, which is often not viewed as motivated in the same way as the Westernized world, the assumption that motivation is a real and vital driver of behavior may not apply (Canguilhem, 1991). Instead, the bricoleur may operate based on unknown drivers viewed as superficial or strange. This action highlights the importance of recognizing that not all individuals or cultures view motivation in the same way and that there may be other intangible drivers of behavior that are not yet fully understood.

The notion of the soul, including its association with motivation, has been transformed into a measurable and fixable material (Edwards, 2019), employing mechanical explanations and restoration techniques. However, it is crucial to acknowledge that these concepts may be culture-bound and not universally applicable (Canguilhem, 1991). Although motivation is a complex construct that influences behavior, not all individuals or cultures perceive it similarly. Other intangible drivers of behavior may exist but are not yet fully comprehended. Therefore, while the soul has become a mechanical system for explanation and restoration, it is vital to recognize its cultural specificity (Grenham, 2020).

One way of approaching the study of motivation is through a materialistic and rational perspective, as proposed by Hopp (2018). In his analysis of lean work, which aims to minimize waste and increase efficiency, Hopp suggests that motivation can be understood as a measurable quantity based on other influencing factors. He provides an example by Maier (1953, as cited in Hopp, 2018) that uses a formula to calculate motivation based on job performance and individual ability, expressed as Job Performance = Ability × Motivation. However, Hopp (2018) rejects this equation as problematic due to the difficulty in quantifying the different elements involved. Instead, Hopp (2018) suggests incorporating the idea of the three H's: Head, Hands, and Heart. The three Hs represent the concrete, physical, action-based orientation (Hands), the conceptual, intellectual, theory-based orientation (Head), and the emotional, empathic, ethics-based orientation (Heart). According to Hopp (2018), human beings operate on all three levels in life and work.

This approach highlights the interrelatedness of the mind, body, and soul, as well as the importance of considering multiple factors in understanding motivation. Hopp's (2018) analysis also emphasizes the need to move beyond simplistic formulas and adopt a more holistic perspective in examining motivation. This perspective may be instrumental in cross-cultural research, where different cultural values and beliefs may impact how motivation is understood and expressed. However, this has limitations based on definitions of factors and particular attitudes towards methods and production. While the study of motivation remains a crucial area of research in organizational psychology, different approaches and perspectives offer valuable insights into this complex construct. Incorporating the three H's, as proposed by Hopp (2018), provides a framework that has the potential to be more inclusive, but remains problematic as a search for a mechanized universal truth.

3.17 The Influence of Mechanics on Our Understanding of the Body and Soul

According to Kantor (1963), the way we think about, teach, and label the human body has been heavily influenced by mechanics. This mechanistic perspective on understanding the physical aspect of human existence can be traced back to Aristotle's concept of material, efficient, formal, and final causes, which offer a framework for comprehending the fundamental physical components of being. While material and efficient descriptions are evident in mechanical ways of knowing, formal and final causes provide a less evident physical representation, leaning towards natural explanations that lead to the consideration of the soul and its relative importance to the body.

During the Renaissance, Westernized psychological thought became intertwined with theology, and man's salvation was the primary concern. In medieval times, the "besouled" man was the object of intellectual concern, and theological and church civilization placed man and his habitation at the center of the universe. As a result, his essential behavior was envisioned as a spiritual order, and man, in part at least, was removed far from his actual place in a spatiotemporal world and made into a being who, because he was endowed with a soul, was in part akin to God and the angels (Kantor, 1963). However, as regimes of truth based on Cartesian methods and sensibilities embedded in science, medicine, and engineering improved, there has been a noticeable shift in how and to what extent one can explain the body and soul. Thinkers began to consider the mechanical and technological advancements of the time, leading to a more comprehensive understanding of personhood's physical and material aspects (Kantor, 1963).

Rationalization and science became so entrusted in explaining the physical body that shifts in psychobiology (relating biology to psychology), or the relationship of interest between the body and soul, began to change, as shown in Appendix 1 (Kantor, 1963). “With the advancement of exact scientific knowledge in biology, especially physiology, and neurology, the original relations of body and soul were reversed (Kantor, 1963, p. 361)." During the Enlightenment, a shift occurred in how the physical body and the non-material soul were perceived. Descartes challenged Aristotle's notion of formal outcomes, placing them outside the physical world into non-material entities like theology and those which would later become the basis for psychology (McGuire, 2012). However, many thinkers and philosophers of the time still sought ways to explain the non-material through mechanical means. Automata[52], in particular, fascinated elites, thinkers, and mechanical types for centuries, as it challenged observers to consider what constitutes living and non-living using methods of mechanics, mathematics, and consciousness.

In the Enlightenment era, there was a notable shift in the way the physical body and non-material soul were perceived, with many thinkers seeking to explain the non-material through mechanical means. This mechanistic approach has been prevalent throughout history, with mechanics serving as a way of understanding the body and its processes. The influence of mechanics can be traced back to Aristotle's material, efficient, formal, and final causes, which provided a comprehensive understanding of personhood (Kantor, 1963). Even today, this approach remains prevalent in various fields, such as medicine, biology, and psychology (Miller & Rose, 2008).

[52] In this period, the body was envisioned as a mechanical apparatus capable of carrying out specific movements and actions to produce certain results. Numerous manikins that operated using trains of wheels or hydraulic pressures were made, capable of marching, striking bells to mark the passing hours, and performing many other exciting acts (Kantor, 1963). At the time, anatomists also made copious use of the analogy with mechanics by viewing the human body as a series of interrelated members capable of mechanized actions.

The integration of mechanical and technological advancements into our understanding of the body has led to a more nuanced understanding of personhood (Dorst, 2015). Moreover, the machine metaphor has been used to understand the relationship between the body and the soul. In this metaphor, the soul is considered part of a whole, with no part having a goal within itself but as a part of a machine designed to certain ends (Dorst, 2015). This adherence to the idea of Aristotelian mechanics opens a space for systems to be applied as a way of explanation and manipulation. Just as humans create machines with particular goals in mind, considering the soul as a machine might allow for a similar opportunity. In this way, the mechanical soul becomes a place of interest, design, and control.

However, it is crucial to recognize the limitations of the mechanistic approach and the complexity of the human body and its processes. Reducing personhood to a mechanical system can oversimplify the complexity of the body and lead to an incomplete understanding of it, as noted by Dorst (2015). Hence, it is essential to recognize the multifaceted nature of personhood and avoid the use of the machine metaphor.

The mechanistic approach has a long history of serving as a way of understanding the body, and its influence can be seen throughout history. While this approach remains prevalent today, it is vital to recognize its limitations and the complexity of the human body and its processes. Therefore, a comprehensive and nuanced understanding of personhood requires a recognition of the limitations of the mechanical approach and a consideration of alternative approaches.

3.18 Conclusion

The concept of Taylorism provides a lens through which to consider the body as a productive and efficient machine and the resulting ideas about human behavior that emerged. Rooted in Gribeauval's ideas, systems of efficiency and the conditioning of one's will in Taylorism are evident in the psychology of the early 20th century. John B. Watson, the founder of behaviorism, argued in 1924 that "the human body…is not a treasure house of mystery but a very commonsense kind of organic machine" (Watson, 1966, p. 49). Watson dismissed the existence of the soul outright due to its non-materialism, reflecting the prevailing materialist view of the body at the time (Kantor, 1963).

The mechanical construction of the body was in line with the broader mechanization of society, exemplified by the advent of the Model T Ford in 1908 (Kantor, 1963). Watson even likened the human body to an assembled organic machine, drawing a parallel between the body and the car (Watson, 1966). This reductionist view of the body was congruent with the era's trust in science, engineering, and technology as pathways to comprehensive knowledge, including that of the soul (Kantor, 1963). However, this was not a novel idea. Descartes similarly regarded the physical world as mechanical, viewing living things as automata (Mix, 2018). The mechanical philosophy can be understood through the lens of the machine metaphor, ontological elimination, and etiological reduction (Mix, 2018). Kantor (1963) notes that these ideas can be combined in various ways to make arguments. In the above analysis, the employment of etiological reduction and the machine metaphor helps to explain how Taylorism and material engineering and design opened the door to the mechanization of the soul.

Descartes' concept of dualism proposes that the body and soul have a mechanical character and a close interaction. This view became a way of explaining the soul through science and technology, providing a means of understanding intricate mechanisms with controls located within the soul. As scientific knowledge expanded, more elaborate constructions developed regarding the localization of psychic functions in the nervous system, particularly in the brain (Brown, 2018). The soul became scientific because it was considered to belong to and be controlled by the body within a system. This approach enabled the application of scientific measurements, quantifications, and standards to the soul (Kantor, 1963).

The idea of the mechanization of the soul is closely tied to the mechanical philosophy, which holds that all natural phenomena could be explained by applying mechanical principles (Kantor, 1963). The mechanization of the soul refers to the process of reducing the soul to a mechanical entity without considering any absolute causation or final causes such as non-materialism or immortal influences.

In today's society, engineering is often viewed as a progressive and forward-thinking field, with engineers as problem-solvers who create and implement innovative solutions. However, this perspective neglects the potential biases and inequalities inherent in the methods and outcomes of engineering. The concept of the bricoleur, introduced by Levi-Strauss, offers a contrasting view of engineering as a backward-looking and ritualistic practice. This dichotomy raises essential questions about the nature and purpose of engineering and highlights the need for critical reflection on the values and assumptions that underpin engineering practices.

As engineering has evolved, the focus has shifted from tangible outcomes to the intangible, such as measurement and prediction. This shift has created new challenges around issues of equity, autonomy, and normality. For example, defining outcomes and solutions based on non-material measurements can be biased and constrained, leaving us to question whose desires are prioritized and who benefits from the outcomes. Furthermore, the pressure to achieve specific outcomes can come at a significant cost, potentially undermining the values and ethics that should guide engineering practices.

Mythology plays a vital role in shaping beliefs about power and authority and can be used to justify and reinforce certain forms of governance. Similarly, engineering practices can be influenced by underlying mythologies and beliefs about progress, efficiency, and innovation. Critical reflection on these mythologies and their impact on engineering practices is essential to ensure that engineering serves the broader social good and aligns with ethical principles. Engineers can play a more active role in shaping a more equitable and sustainable future by questioning and challenging these underlying beliefs and assumptions. The dichotomy between the bricoleur and the engineer offers a helpful framework for considering the values and assumptions that underpin engineering practices.

Chapter 4 Engineering the Engineer

4.1 Engineering the Engineer: Reflections on the Impact of Engineering Principles on Schooling and STEM Fields

Engineering, as a discipline, has traditionally been associated with problem-solving using tools and techniques. However, its impact has grown rapidly, expanding beyond its roots in fields like civil and mechanical engineering to encompass a wide range of disciplines that rely on calculations, evidence-based decision-making, efficiency, and innovation. This exponential growth has led to the concept of the engineer permeating many different knowledge-making systems. The way we understand the role of the engineer has shifted as well, from a narrow professional or disciplinary field to encompassing more of a mindset and problem-solving approach. Despite its successes, there appears to be a prevailing mindset among engineers that extends beyond the mere implementation of tools and techniques. This has resulted in cultural diversity being rarely integrated into the foundational structures, systems, and analysis. The complexity of engineering's ways of thinking has overshadowed or outright obscured cultural and spiritual approaches to problem-solving. This occurrence is not bound to engineering itself but to those disciplines which have been "engineerized" or have had engineering principles and practices applied to their own fields of study.

To create better engineers, it is necessary to reflect on and strengthen the idea of the engineer. This requires turning the engineering system back on itself, so that the very systems and ideas that led to the creation of the engineer are now responsible for engineering the engineer themselves. This concept, "engineering the engineer," is critical to ensuring that engineers are taught not only about methods and techniques but also about moral values and ways of being, and that cultural diversity is integrated into engineering's foundational structures, systems, and analysis. As engineering continues to spread, it is necessary to consider the equitable and consciences approaches that are being incorporated into educational programs to ensure that the next generation of engineers is well-equipped to tackle real-world problems in systematic ways.

The ubiquity of engineerization has become foundational in many aspects of schooling. Its roots in early Deweyan incorporations of the scientific method as a means to rational problem solving (Rudolph, 2019; Cowles, 2016) exists today in a modern mode which incorporates technologies which has shaped new ways of acting, thinking, and feeling. One need only go to the iPhone app (Apple Inc., 2022) store to find new ways to let the technology into our lives. As in most engineering systems, efficiency is vital, as it allows for the upkeep with the spread of technology happening beyond the material world. The new world of webs and nets seem to have formed its own spirituality similar to how some have considered science as a form or religious dogma. And while devices which connect us with this new form of non-materiality are surprisingly intuitive and considered well-engineered, the classroom is one of the key places where we learn to create and interact with the material and non-material worlds of engineering.

The engineering mindset is not just for engineers. As such, this framework of thinking has formed boundaries around the engineered and the engineerized, limiting the scope of what is possible. Of course, calls for creativity in engineering exist, but they too are constrained by disciplinary commitments such as rationalities, efficiencies, and standardizations. From the perspective of progress, engineering has brought Westernized societies a long way, but has not yet delivered a utopia. Reactions to fears and projections have clouded our path, leaving hope as the only means of advancement. All too often, hope lies in the knowledge and power of the next generation of students who are willing to advance a technoscientific agenda.

The schooling system, as a means of engineering the engineers, has resulted in a circular effect that limits the recognition and access to expertise in STEM fields. The fields of science, technology, engineering, and mathematics are often committed to a singular mindset and disciplinary regime that restricts and deconstructs engineering as a school subject. This creates gates that limit access based on chosen proficiencies and treats engineering as a closed system in itself. Unfortunately, this approach results in a lack of openness towards different cultural inputs and methodologies. In this chapter, the discussion revolves around schools in the United States, while acknowledging that the impact of U.S. schools and educational practices in other countries, whether by means of example or colonization, helps sustain certain traditions.

4.2 The Role of Modern Engineering in the Development of U.S. Education and Society in the 20th Century

In the early 20th century, engineering gained prominence in U.S. schools, similar to its emphasis during times of war under Gribeauval's system discussed in Chapter 2. Technological and medical advances during World Wars I and II had a significant impact on the need for engineers. This need was significantly heightened by the technological and medical advancements made during this time. Additionally, in the U.S., urban living conditions, including concerns of child well-being, became problematic to the extent that a range of scientized or engineerized solutions grounded in civil engineering, sociology, and psychology were called for. The latter two were newer disciplines that had emerged from the foundations of science and the applications of practical engineering design, aimed at creating a homologous citizenry from different forms of persons and normalities (Foucault, 1975). Early problem-solving methods in psychology and sociology would soon take on greater scale and higher stakes.

Concerns of the unrest across a warring Europe and later related to the Cold War would reestablish a design of the physical and mechanical means of science, technology, and engineering. While those working in psychology and sociology progressed in their own defined areas of expertise, a return to a more physical form would push demands. Juvenile delinquency and child development would remain causes for concern, but the horrors of war, genocide, and nuclear annihilation increased fears and the need for security. Institutions of education would become central to such concerns. Both the war and reform efforts required complex systems to be developed and overseen by a new assembly of scientists, technicians, and engineers (Rudolph, 2019).

After World War II new wants and desires drove a technoscientific explosion driven by new ways to travel, manufacture, and manage the home. Leisure and status as a part of a new seemingly peaceful existence would increase demand for electrical appliances, transistor radios, and television sets. Progress was brought to the people by means of the engineer. But this change in cultural and societal factors was not all optimistic. The technical solutions which made life easier for some in the United States had the ultimate responsibility of keeping them safe as well (Savage, 2010).

The launch of the first artificial satellite, Sputnik, by the Soviet Union in 1957 triggered significant concerns in the United States prompting a renewed focus on science education to compete in the Cold War space race. With the launch of Sputnik, technology was viewed as a potential life-saver or guardian. Scientists, politicians, and educators recognized the need to train and retain individuals in fields such as science, mathematics, and engineering (Savage, 2010). Such fears played a crucial role in shaping the development of those who aspired to become scientists over those who chose alternative career paths. For instance, the 1944 Education Act mandated new types of testing for 11-year-olds, which were designed to sort students into higher-intellect and lower-intellect schools[53] (Popkewitz et al., 2020). Tracking students in this manner reflected remnants of the eugenics movement, which had been discredited in the wake of Nazism, but continued to resurface in various covert forms, even in contemporary times.

The launch of Sputnik by the Soviet Union in 1957 not only had a significant impact on the fears of the people of the United States, but also triggered a series of changes in educational policies that would shape the curriculum design of the country for decades to come. The increased focus on science education was just one aspect of a larger movement towards designing curricula that could better serve the needs of society. As Petrina (2004) notes, curricula in the 20th century were subjected to designs that were heavily influenced by socio-political concerns, including those related to medical and military interests, Cold War politics, and economic pursuits. The resulting curricula reflected a combination of economic and pragmatic disciplinary forms with

[53] The use of intelligence tests in a society that values national exceptionalism and perceived meritocracy is a way to measure and classify individuals based on specific knowledge, as exemplified by MENSA, a group established in 1946 to unite individuals who score in the top 2% of IQ tests. According to Pierce's (2012) perspective, such tests enable sorting and categorization based solely on quantifiable results without regard for other factors such as social implications.

sensibilities of human experiences in schools. While certain concessions were made to appear democratic and free, the assumptions underlying these curricular designs were ultimately based on which knowledges were deemed important and how they should be attained (Apple, 2014; Petrina, 2004).

Educational theorists of the early 20th century, such as John Dewey and Lev Vygotsky, focused on civic and moralizing education that was grounded in ideals of democracy and collaboration. Their contributions have led to numerous educational research pursuits over the last century, with student agency, cooperative learning, and practical applications of education being central themes (Popkewitz, 1998). The perception of the engineered engineer's pragmatic ways, ingenuity, and exceptional work ethic align with these themes of education, as well as with the rationality of scientific thought and the ability to create a version of "the good life" for those who choose to be a part of it. Together, these factors have shaped the development of the modern engineer in the 20th century, resulting in the heroism and mythology of highly skilled and specialized experts who are considered vital to the advancement of new technologies and systems.

The significance of science education and engineering was further emphasized during the Cold War and subsequent technological advancements, as concerns about nuclear destruction and the launch of Sputnik by the Soviet Union drove a renewed emphasis on these fields. This renewed emphasis has had a significant impact on modern curricula, with the contributions of educational theorists aligning the pragmatic mindset of engineers with democratic ideals and practical applications of education. However, the narrow scope of what engineering is methodologically, epistemologically, and ontologically and its watered-down expansion into differing realms created a westernized version of practical science. The result is a power assembly which shapes action, thought, and intuition my means of a commitment to a narrow vision of engineering and ways to recognize and solve problems.

4.3 Engineering Prestige, National Security, and the Engineer

From a Westernized perspective, engineers have assumed a crucial and highly esteemed role in popular perception, often viewed as quasi-superheroes. Madhavan (2015) acknowledges this favorable perception of engineers, noting their capacity to create solution spaces comprised of an array of possibilities that offer novel options, conveniences, and comforts that reconfigure prevailing standards of living. Through their tangible innovations, engineers are capable of translating scientific principles into a range of functional technologies that span diverse domains, such as industry, everyday life, recreational pursuits, labor, and survival. The engineering profession, in its purest sense, offers a certain level of accomplishment and social status, as well as a seemingly stable, in-demand, and lucrative career path. Thus, during the early and mid-1900s, parents were swayed by advertisements across various media platforms advocating for an inclination towards engineering education. Engineering was regarded as a venerated and esteemed profession with the possibility of high remuneration and career advancement. Furthermore, with the growth of industrialization and the rise of a technoscientific commitment, engineering was seen as a field with great potential for innovation and progress.

The impetus to promote engineering as a public good arose from similar conceptualizations of education as a societal endeavor that serves the public interest. The idea of public education emerged from the recognition that children had different needs than adults and required separate institutions. In such a state of separation from adults, children were viewed as requiring salvation (Baker, 1998a) through education. Education was seen as a means to provide knowledge, power, discipline, and organizational structures to offer a range of redemptions to those who received it. Baker (1998a) highlights the ways in which knowledge/power is embedded in the child through a child-centered approach to modern education that employs discipline and organization, leading to specific opportunities and limitations for the child. This notion in combination with the framework of engineering education and its offshoots would establish engineering as vital and the engineer as essential. The engineer was iconized as a rugged individual ready to take on a grueling preparation program. According to Ingalls (1924), engineers were "Pioneers who will undertake the arduous preparation and experience necessary to become worthy of responsibility in this field will find a satisfactory occupation among the many activities which engineering represents (p. 47)."

With the design of engineering education in schools and universities worldwide, there emerged a greater emphasis on foundational disciplines such as mathematics, physics, and technical training The emphasis on engineering education in the early and mid-20th century contributed to the differentiation and hierarchy of various engineering programs. This emphasis was further supported by a concentration on project-based activities and problem-solving training, which introduced structured ways of thinking based on analytical, investigative, and rational processes, combined with the material-focused learning inherent in the practical application of physical sciences. This approach to engineering education has been recognized as effective in preparing professionals who can address intricate problems and promote innovation in a wide range of fields. With a complex system of educational design at work, the need for the gathering of bodies and minds became the next hurdle.

In response to concerns about a deficiency of engineering talent, a concerted effort was made by scientists, educators, and socio-political influencers to revise established curricula. One such measure involved a greater emphasis on engineering and its practical applications within physics classes (Rudolph, 2019). The development of programs such as engineering-physics addressed the interests of students in the physical sciences while also providing them with the skills and job-readiness required for careers in technical fields, such as mechanics, materials science, and electrical engineering. The necessity for engineers soon extended beyond tertiary education to include primary and secondary schools in the U.S. However, the function of engineering evolved to involve matters of national security. From Gribeauval's war machines to the production of materials for both humane and inhumane purposes during the World Wars, engineers were perceived as protectors of nations, ideologies, and ways of life. Engineering procedures and technological advancements were seen as resolutions to issues of warfare, social concerns, and even psychological worries such as nuclear fears, economic instability, and the alleged decline of American Exceptionalism.

The perceived shortage of engineers in the United States was considered a threat to the American Way and its ideals of progress and exceptionalism (Van Engen, 2020). The changes in education to meet the need for more engineers led to a greater emphasis on engineering design, hands-on experiences, and practical applications of physics concepts. These programs were designed to create a specific type of engineer, one who would contribute to making the U.S. exceptional again. This model engineer is characterized by logical and systematic rationality, practicality, analytical thinking, and collaboration. These focuses aimed to better prepare students for careers in engineering and related fields.

The formalization of engineering education in schools and universities has led to a greater emphasis on foundational disciplines such as mathematics and physics, as well as hands-on experiences and problem-solving training. However, the racialization of engineering as a means of obtaining and wielding power in society has persisted. Despite efforts to promote equity related to gender and race, the changes in education have aimed to create a specific type of engineer, one who would restore Americas technical status. Overall, engineering education has been shaped by societal needs and ideals, leading to the development of a certain type of engineer who is disciplined to tackle specific problems and drive specific innovations.

4.4 The Impact of the Cold War and National Crises on Engineering and Science Education in the United States: From Sputnik to A Nation at Risk

Engineering education underwent a surge in growth and expansion after World War II, prioritizing the production of engineers capable of designing new technologies for both military and civilian use. This emphasis also had an impact on other scientific fields, as well as liberal arts and humanities. The Cold War intensified this trend, as the US and the Soviet Union engaged in a technological arms race, vying to create more advanced weaponry and technology. Consequently, engineering education became increasingly specialized, emphasizing the development of technical expertise. Funding for research and development was provided by the government and industry, fostering a close relationship between universities and corporations

(Jasanoff, 2019). However, critics argued that this led to a narrow focus on practical skills in engineering education, neglecting the broader social and ethical implications of technology (Haraway, 2004).

The launch of Sputnik had far-reaching implications for science education in the United States. It ignited a sense of urgency among the American public and government to improve science and technology education, as it was perceived that the US was falling behind in the space race. The response to this perceived threat (amongst others) was the National Defense Education Act (NDEA) of 1958, which provided funding for science and technology education in schools and universities. The NDEA aimed to develop new curriculum materials and teacher training programs, with a particular emphasis on mathematics and science education.

Between 1957 and 1969, the Space Race was in full effect. The US launched Explorer 1 in 1958 and began manned missions with the Mercury program in 1961. Soviet cosmonaut Yuri Gagarin was the first human in space, followed by American astronaut Alan Shepard. In 1963, President John F. Kennedy announced a national goal of landing a man on the moon and safely returning him to Earth before the end of the decade, leading to the development of the Apollo program which, on July 20, 1969, successfully accomplished this goal. The moon landing represented a significant victory in the space race against the Soviet Union as it showcased the technological prowess of the U.S. at a time when science, technology, and engineering moved quickly on the development and transport of nuclear weapons intercontinentally. The decades that followed would see a variety of a games of one-upmanship between the U.S and the Soviet Union until

1991 saw the end of Soviet rule. However, the demise of the Soviet Union and the quelling of nuclear obliteration was replaced with a new set of fears for the people of the U.S.
In the Sputnik era, the focus of American citizens' anxieties shifted from the threat of nuclear war to economic risks that could endanger national pride and quality of life. This change was exemplified by the 1983 report A Nation at Risk by The National Commission on Excellence in Education, and later by the 2005 Rise Above the Gathering Storm reports by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine in the United States. A Nation at Risk emphasized the decline in the quality of education in the United States and the country's lagging behind other nations in educational achievement. This report sparked a national dialogue on education reform and led to numerous modifications in the U.S. education system, including increased accountability measures, testing, and efforts to improve teacher quality and academic standards. It also had a significant impact on science education, stressing the need for greater emphasis on science, math, and technology education to improve academic performance and economic competitiveness.

Thomas Friedman (2007), an educational policy analyst, alarmed New York Times readers with reports of a decline in American Exceptionalism concerning science and our shortcomings in comparison to other industrialized countries. [54] According to Pierce (2012), the Rise Above the Gathering Storm report conveys a sense of foreboding about the future and safety of the United States. The report emphasizes the need for scientific literacy among citizens, as the world

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[54] Rudolph (2019, p. 203) states that in his book "The World is Flat," Friedman criticized the American education system for lagging behind other nations in the field of science. The 9/11 terrorist attacks of 2001 left the American public feeling anxious and seeking a sense of security, both physically and economically. They wanted to promote progressive ideals and scientific advancements that would enhance the nation's reputation. To achieve this objective, they stressed the importance of "authentic" scientific practices, such as utilizing modern technologies, expertise, and fostering collaborative learning opportunities.

becomes more and more influenced by science and technology. It also stresses the importance of the next generation of scientists and engineers in tackling persistent national issues, such as national and homeland security, healthcare, energy supply, environmental conservation, and economic progress.

As education reformers and concerned citizens became increasingly anxious about the threats of war, Russian missiles, and the perceived benefits of economic security, curricular designers turned towards a more disciplinary approach to education. Politically motivated educational methods incorporated a narrowly defined view of rationality, economic interests, and salvation, while pre-structured knowledge was often taken for granted as common sense and delivered in distinct units that set it apart from more practical approaches (Apple, 2014). This mode of thinking created a distinction between ways of learning and knowing that were based on abstract and complex ideas versus those based on obedience to methods and concrete tasks. This differentiation mirrors the difference between a bricoleur and an engineer, where assumptions of fixed levels of concrete thinking resulted in the "savage" method of production rather than the more advanced approach of the engineer. [55] Furthermore, this process carries immense significance for the values of American Exceptionalism and the American way of life. Central to the push towards science as a means of salvation was the consideration of science, particularly scientific literacy, on a national political level and in educational institutions.[56]

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[55] Traditionally, there has been a bias against practical curriculum designs, leading to the perception that subjects like business, technology, and home economics primarily focus on technical skills and utilitarian purposes. However, Petrina (2004) argues against this view, stating that such subjects have always had utilitarian purposes but are no less valuable or theoretical than other subjects like the sciences, math, arts, or humanities.

[56] Scientific specialization among experts has created difficulties in maintaining their authoritative status. The increasing complexity of knowledge has made it challenging for the general public to understand or become informed citizens, which strains democracy as crucial societal issues become more complicated. Science

The educational actions that involve sociopolitical, military, and industrial efforts have been the subject of various criticisms. These critiques are often centered around the consolidation of powerful institutions, such as their motivations and goals, the narrowing definition of science and science education, and the discouragement of genuine interests in favor of competitive priming, among other things (Giroux, 2008). Scholars argue that these narratives have reinforced dominant power relations in society and have been used to justify the increasing corporatization and militarization of education, which has narrowed curricula and ignored arts and humanities.

Moreover, the emphasis on science and technology education has led to a reductionist and instrumental view of knowledge, which recreates knowledge as a commodity to be acquired and used for practical purposes rather than as a means of developing critical thinking and social consciousness (Freire, 1970). This view of knowledge reinforces dominant power relations in society by promoting a technocratic worldview that values efficiency, productivity, and economic growth over social and environmental justice.

Science and Technology Studies (STS) scholars have also critiqued the ways in which society understands science. One argument suggests that the construction of science as a cultural and social entity creates hierarchies and intermediaries of people and materials in science, which creates standards and positions involving the knowledges that count as science (Latour & Woolgar, 2013). Additionally, deterministic views of technology as an inherently logical means

philosophers such as Conant (1951) and Kuhn (1962) have called for scientific literacy that is accessible to the layperson across all scientific disciplines. Laypersons' comprehension of science has evolved from the ability to practice and theorize science to a broader, universal, and appreciative understanding of science based on trust and rationality. Cohen-Cole (2014) notes that this shift towards a more accessible form of scientific literacy is a response to the challenges posed by the increasingly complex nature of scientific knowledge.

towards progressivism (Jasanoff, 2015) and the reluctance to see technologies and methods as actors within a scientific network create reductive assurances of science, technology, and engineering that negate the complications of experiences and cultural difference (Latour, 1986). Lastly, feminist scholars have argued that science and technology have been shaped by patriarchal and sexist assumptions, and that this has had negative consequences for women and marginalized groups (Hardaway, 2006).

The evolution of science education in the United States has been shaped by numerous factors, including war, competition, and research findings. World Wars I, II, and the Cold War significantly influenced the direction of science education, with an increased focus on engineering education and technical expertise during this time. The launch of Sputnik in 1957 further intensified this emphasis, resulting in the National Defense Education Act of 1958 and renewed efforts to improve science and technology education. However, it is important to recognize that science education has a rich history spanning thousands of years, with early civilizations such as the Greeks and Egyptians possessing knowledge of what we, in the present, recognize as scientific concepts. Although this early form of science education was passed down through oral tradition and early forms of written communication, modern science education has been systematized to include various methodologies and ideologies. While an exhaustive account of this history is beyond the scope of this discussion, it is worthwhile to trace a few lines of the foundations of science education and the philosophies of making science accessible to children.

4.5 Tom Telescope and the Enlightenment: Science for Children

John Newbery, namesake of the Newbery Award[57], wrote children's books under the fictional name Tom Telescope in the 18th century, and his book "The History of Little Goody Two-Shoes" featured a wise and curious schoolmaster who encouraged students to explore science and the natural world. The dissemination of Enlightenment ideas was facilitated by Newbery's introduction of Tom Telescope to a wide audience of children, utilizing the thriving shipping industry and significant publishing presence in his home of Antwerp, Belgium. This city became a hub of educational transformation because of the European demand for textbooks and curricula, and scholars like John Amos Comenius and Desiderius Erasmus took advantage of Antwerp's publishing technologies to disseminate their ideas.

Newbery believed that science was crucial for children because it had the potential to develop progressive thinkers, social saviors, and national leaders inspired by Enlightenment dispositions. He believed that science could be accessible and enjoyable for children if presented in a clear and engaging manner. To achieve this, he wrote his books using simple language and clear illustrations, as seen in his series of books called "The Newtonian System of Philosophy: Adapted to the Capacities of Young Gentlemen and Ladies."[58] These books featured a much younger Tom who, despite his youth, lost little of his scientific spirit and knowledge. The books portrayed Tom as a toddler-like teacher who introduced the principles of Newtonian physics and astronomy to establish access for children (as well as unfamiliar but interested adults) and were

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[57] The Newbery Medal is a literary award given annually by the Association for Library Service to Children, a division of the American Library Association. The award is given to the author of "the most distinguished contribution to American literature for children." The award is named after John Newbery, an 18th-century English publisher of juvenile books.

[58] Often referred to as “The Newtonian System” as I will do for brevity throughout.

reprinted and passed down over generations. Newbery's writing style made physics accessible to a general audience, and he engaged multiple generations of children.

Newbury’s Newtonian System series was based on the writing of John Locke's [59] "Elements" (Secord, 1985). In these books, Tom’s science-based lessons impart the scientific writings of Locke, morality lessons of the church, and progressive ideals intended to let science and technology lead society toward a more utopian existence. The reverence for Isaac Newton's methods and those of other famous scientists of the time is entangled in the books of “the Newtonian System.” Such methods would include the use of a variety of scientific and instructional methods, including diagrams, illustrations, and experiments, to produce and explain concepts such as gravity, motion, and optics.

4.6 The Emergence of Childhood as a Distinct Stage of Life and Its Impact on Science Education

In the Enlightenment era, Westernized societies underwent significant reform as they recognized the influence of incorporating disciplines like science into a child's education and began to view childhood as a distinct stage of life requiring a different approach to education. Prior to the 17th century, children were regarded as miniature adults expected to contribute to the household. However, the emergence of new disciplines, methods, values, capabilities, and sensitivities came to fruition as scientific searches for solutions led to new forms of knowledge and rationalities, all in the name of salvation in Western Europe and the United States (Popkewitz, 1998). To secure

[59] John Locke, a prominent philosopher in the 17th century, had a noteworthy impact on the field of education. His ideas on education, particularly on science education, were influential during his time and continue to shape educational philosophy today.

the salvation of society based on a moral code and scientific rationalization, it became crucial to ensure that educational opportunities addressed these requirements. John Locke's concept of tabula rasa, which suggests that individuals are molded by their environment and experiences, posed a challenge to traditional religious thought by proposing that children could be educated and shaped to become productive and virtuous members of society.

Cultural movements during the Enlightenment era reformed Westernized society by calling for an assembly of rational and scientific thinking and rejecting dogmatic traditions. Families were restructured as parents used nurturing and guidance instead of harsh punishment and bodily harm. Science influenced science standards, objectivity, the control of nature, and the significance of quantification. As these new rationalities became regimes of truth, science's influence became evident in social and educational realms, politics, and economics, creating new forms of regulation and communal controls.

The emergence of childhood as a distinct stage of human development led to the creation of new scientific disciplines, such as developmental psychology and child development. These fields focused on understanding how children learn and develop, which had a significant impact on science education by positing the notion that educators better understand the needs and abilities of children (Chudacoff, 2007; Cross, 1999). Additionally, Societal expectations and educational movements were being driven by the desire to create rational, systematic, and sensible children that can contribute to society's progress. This desire is linked to morals and divinity, as well as Locke’s notion of the child as a "tabula rasa" or blank slate. However, this newfound emphasis on educative discipline and societal expectations may have resulted in children losing their agency and becoming total subjects of various forms of power.

Locke's influential ideas about education emphasized the need for young gentlemen to obtain a cultured acquaintance with science. His influence and the newfound embrace of science increased the demand for science education to be included with moralizing and practical forms of teaching and learning (Brewer, 1980). During the 17th century, Locke's notions regarding education had a noteworthy effect on children's development, emphasizing the importance of self-determination and discovery in science education. Even today, his ideas continue to shape educational philosophy. Prior to this, prevailing beliefs about education were different. For instance, during the emergence of the Calvinist Protestant movement, parents prioritized work and productivity instead of self-determination and exploration. They instilled a disciplinary approach of "spare the rod, spoil the child," which involved using violence to discipline children while they worked, affecting both their physical and mental well-being. (Brewer, 1980). This fear of God helped create an industrious state and would later form the cornerstone of Taylorism.

In modern times, the concept of childhood has given rise to a system where specific forms of control are desired, and technologies enable ideas to become normalized objects, carrying those ideas across time. Controls of life exist in various forms, such as books, laws, pedagogies, and technologies (Foucault, 1990). New modes of child-rearing would enact certain technologies that instilled favoritism in the form of work-ethic, social interactions, and obedience over the unemployed, the “anti-social”, and the criminal. Such forms of child-rearing shifted the focus of discipline from physical and violent forms to more psychological forms (DeMause, 1974). The emergence of new ways of knowing related to child-rearing, child-discipline, and child-development led to a change of new technologies of the self, including normalizations of the self and familial hygiene, public health and safety, and the consumer culture (Zelizer, 1994).

The emergence of childhood as a distinct stage of human development has led to the creation of new social and scientific disciplines which have impacted science education by better understanding the needs and abilities of children (Van der Walt et al., 2016). The societal expectations and educational movements that followed have emphasized the need for rational, methodical, and sensible children, leading to new forms of control and discipline. These controls exist in multiple forms have led to the emergence of new ways of creating children, with internalized conflicts of the self-becoming a battle of the soul (Rose, 1992; Foucault, 1990).

With the increasing rigor and systematization of science, the assemblage of science, technology, and engineering has been validated by those who employ a prophylactic and progressive attitude towards societal reformation. One such reform-minded educator was Jean-Jacques Rousseau, who believed that exploring the natural world while avoiding man-made societies helps to develop curiosity and creativity (Rousseau, 2018). Rousseau promoted the idea of a social contract, which would enable people to live freely and equally, with the state being responsible for safeguarding their rights. His approach to education emphasized the importance of natural experiences over traditional methods, advocating for self-discovery and individual growth for children. Rousseau's vision inspired later progressive educators such as Johann Pestalozzi, Fredrich Frobel, and Maria Montessori, all who were responsible for a number of science-education initiatives between the 19th and early 20th centuries (Saracho & Evans, 2021).

Pestalozzi, Frobel, and Montessori proposed profound ideas that shaped schooling in a particular way, including child-centered classrooms and active engagement. These ideas focused on using material items to create abstract scientific knowledge and encouraged students to link doing with thinking. However, a commitment to materialism in education raises questions about the perception that knowledge is represented only by materials and the potential for objectification of nature and commodification of knowledge (Haraway, 2004). Moreover, the westernized centrality of these ideas may not have been equitable historically, as marginalized populations were often omitted from science meaning making. The Enlightenment era marked a significant shift in attitudes towards science education, with a focus on observation, experimentation, and hands-on learning becoming increasingly normalized. Early on, science education took place in universities and private academies where children from affluent families were typically educated. Movements to bring science into primary and secondary schools were backed by a society and scholars who had faith in science as a progressive technology. The philosophies and pedagogies put forth by Pestalozzi, Frobel, and Montessori continue to influence the development of young scientists in many classrooms today.

4.7 Dewey and the Engineerization of Science, Non-science, and the School

In his book "How We Think," John Dewey proposed a new approach to teaching problem-solving skills to students, which involved the systematic application of observation, data collection, hypothesis testing, and drawing conclusions - an approach that bears a resemblance to the generic form of the scientific method (Rudolph, 2019). However, Dewey's commitment to pragmatism suggests that this methodology is more about the application of the pursuit of new knowledge beyond just science. He argued that this practical approach was beneficial not just in engineering practices, but in any subject area, and that the engineering of science itself could be applied to a wide range of places and events. The integration of practical scientific or engineering methods would transform the ways in which we create knowledge in numerous areas, including disciplines not traditionally founded in engineering approaches like chemistry and genetics, and would provide a catalyst for future technologies like computers and artificial intelligence. As trust in engineers and engineering practices grew throughout society, scientific methods, standards, and verification became more prevalent in other fields. However, as engineering practices became more defined, certain ways of controlling nature often had unintended consequences.

In higher education, engineering practices opened up new possibilities for the decoding and pushing the boundaries of nature, value, utility, and ethics (Pierce, 2012). In the last 150 years, techniques from engineering and science were used to interpret and understand the theory of evolution, organize and predict practices in genetics, and develop mechanical ways of knowing and manipulating the biotechnology industry. Dewey's ideas about reflective thinking and the integration of engineering practices had a significant impact on education and knowledge creation, but their potential consequences must also be carefully considered. According to Gough (1984 in Barry et al., 1996), the reapplication of engineering principles outside of the physical world has been inconsistent and can lead to systemic inefficiencies in creating an equitable society. This problem arises when advocates of social engineering prioritize outcomes over considering the effects of the system itself, resulting in regimentation and order becoming a way of avoiding fears and risks.

American philosopher and psychologist, William James' [60]philosophical pragmatism greatly influenced John Dewey's educational philosophy, which emphasized the interconnectedness of thinking and doing in the learning process. Dewey believed that this approach could help children understand the connection between learning and active participation in a democratic society. By teaching children to think and act, Dewey aimed to prepare them for meaningful civic engagement. He viewed education as a rational process of investigation, problem-solving, and analysis that resembled the scientific method, consistent with the principles of democracy. Each classroom represented a microcosm of relationships within a larger community called a school. In Dewey's view, a fully-formed rational micro-society within the classroom could model a larger progressive society. He emphasized the importance of democratic relationships in the classroom and shifted the focus of educational theory from the institution of the school to the needs of the school's students. Dewey also maintained the importance of integrating the body, mind, and soul into an ever-changing technoscientific society. As the concept of modern childhood became a dominant principle, Dewey saw the need for a child-centered education that instilled morals and values upon the blank slate of the soul.

Dewey's notion of a Democratic science education creates a cover for the implementation of science formed and delivered through an idea whose power is foundational to Westernized societies and synonymous with equity in the United States. The STE assemblage and a commitment to efficiency and practicality pushed a progressive agenda in which countries like the United States would showcase. Engineering and technology helped to create an industrialized

[60] William James is considered to be one of the founders of modern psychology and is known for his contributions to the study of pragmatism, the psychology of religion, and the philosophy of mind.

nation which would be the model for many nations over the 20^{th} century. Contributions to such economic growth and prosperity in the form of scientific innovation, technological influence, and engineering design would help to create model citizenship by producing jobs and the avoidance of idleness. Such concepts along with the virtues which underly them build towards the idea of American Exceptionalism and the idea of superiority etched into the nation's foundation. Of course, such ideas are often racialized or neglectful of the contributions of the masses. Project-based learning, design thinking, and maker education have emerged as new forms of teaching and learning in schools influenced by these Deweyan views. These pedagogies foster hands-on learning, problem-solving, and critical thinking skills. Bak (2020) notes that these approaches challenge the traditional notion of who can be an engineer and enable students to develop their technological and engineering skills. However, this focus on science, technology, and engineering may lead to the devaluation of other important subjects, such as arts, humanities, and social sciences, perpetuating stereotypes and limiting opportunities for some students.

Critics have raised concerns about the narrowness of these approaches and their failure to incorporate diverse perspectives and knowledge systems (Zinn, 1990; Nussbaum, 2016). Winner (1993) argues that the false assertion of science, technology, and engineering as value-neutral has resulted in secondary problems from standardized and disciplined solutions. Technological determinism (Feenberg, 2012) and the lack of diversity among engineers and environmental impacts are also major concerns (Sochacka et al.., 2018). Other critiques have challenged the origins of engineering education and its role in a narrowed technocratic view (Lyotard, 1987) and furthering the technoscientific world (Latour, 1987). Dewey's dedication to education was influenced by progressivism and American cultural ideals, emphasizing self-sufficiency, hard work, and commitment to a society that aims for equality. However, these ideals also reflected Calvinist ideology, which placed blame for failures on individuals and marginalized communities, leading to self-righteousness and a racialized and genderdized "culling of the herd." The adoption of Deweyan thought in Westernized societies has resulted in the normalization of certain ways of thinking, often missing the bias of human existence in technology and perpetuating narrow perspectives.

4.8 The Mechanization of the Mind and Learning in Science Education

Early Greek philosophy, medicine, and thought have their foundations in the systems of the body. The question of mechanism, which concerns the physical body, and vitalism, which concerns an irreducible vital force, have been used by Western philosophers to contemplate existence and consciousness in both material and non-material realms. Mechanism views organisms as complex machines operating under the rules of physical science, while vitalism considers life systems as transcendent compositions beyond material complexity. The rationalization of scientific ways of seeing the world has led to mechanization becoming not only a way of understanding the physical makeup of science but also of making non-physical aspects visible through science.

Over the past two chapters, I've discussed various ways in which mechanistic explanations are prioritized in science, including in non-physical sciences like biology, sociology, and psychology. These explanations tie back to the concepts of design and engineering, as well as the notion of apperception, introduced in other parts of this work. As a result, the science, technology, engineering assemblage generates certain scientific truths about how truth is constructed, which become immutable mobiles. These mobiles exert dominant influence over institutions, cultures, and time and space. While this dominant theme may provide avenues for further exploration in post-colonialism, for now I will focus on the Westernized realm of educational institutions in the United States.

With the science curricula's focus on rationalized thought, opportunities for vitalism are absent in the science classroom. Vitalism is seen as unempirical, irrational, or mystical and as such have no place in the scientific world (Tobin, 1993). But neglecting those things which have no physicality becomes interesting when the mechanist minded try to bring those things into existence. Large data sets, pseudo causality, and apperception all help to create aberrations or objectify non-physical entities like intuitions, dispositions, intelligences, interests, and feelings. In this way, the act of engineering once again exudes its domain over nature by making a phenomenon that has no physical form into an object of concern. And while the relationship between mechanism and vitalism in science education is complex, there is clearly a dominant way of thinking about the mind which involves objects and objectifying the nonmaterial.

Throughout the 20th century, theories on how children imagine and learn have been influenced by mechanistic modes of thought. Behaviorism, which emphasized observable stimulus-response associations in organisms, dominated psychological thinking. This approach implied a mechanized causality that could be used to condition or train individuals to learn. In Chapter 3, I discussed the development of behaviorism and the ways that individuals can be conditioned to acquire new behaviors. Behaviorism offers a means of integrating internal concepts within the body with external stimuli, whether they are positive reinforcements or negative punishments.

Similarly, the theory of Cybernetics, introduced by Norbert Weiner, posits the mind as a feedback system that regulates behavior based on inputs (Todes, 2014). This feedback system, akin to a thermostat, recognizes variances in responses and recalibrates to improve response as it gathers experiences. In education, Cybernetics theory is seen as a way to facilitate science learning by emphasizing self-regulation and adaptation in the learning process (Tsai & Huang, 2015). In Chapter 3 I show how Nolan (2020) employs Cybernetics theory to explain the inherent differences between a bricoleur and an engineer. The need for training, control, and regulation of the body is suggested as the path towards salvation of the bricoleur. Nolan (2020) argues that the bricoleur's undisciplined and unmeasured responses to environmental factors necessitate regulation and training.

In the classroom, Cybernetics theory can be applied by designing instructional materials and activities that promote self-regulated learning and adaptation. For instance, a math program could act as a feedback mechanism, sorting answers to types of problems and providing corrections through similar problematized problems. In the mid-twentieth century, learning was associated with feedback loops and set conditions as Cybernetics theory became normalized and complex in some regions. The notion of a learning model based on the perception of the unseen mind in conjunction with learning and standard setting would look very similar to the conceptualization of the computer and how it operates. Early computer pioneers Alan Turing and Frank Rosenblatt[61], for example, proposed cybernetic learning as the connection and processing

[61] Alan Turing was a British mathematician and computer scientist who is widely considered as the father of computer science and artificial intelligence. Frank Rosenblatt, an American psychologist and computer scientist who is known for his work on the perceptron, an early type of artificial neural network. His research in the 1950s and 1960s laid the foundation for the development of modern artificial intelligence and machine learning techniques.

of data sets, algorithms, and pattern recognition (Sarle, 1994). However, one may question if these mechanical models accurately reflect the workings of the mind or if they are limited models. Cybernetics theory provides a framework for understanding learning as a feedback system and designing instructional materials that promote self-regulation and adaptation. However, it is important to recognize the limitations of these mechanical models and continue to explore alternative theories of learning.

In the 1960's and 1970's cognitive psychology made the mind appear not in a mechanical way, but more as an electrical model. The model did not physically represent the brain but created mind maps which provided new ways to think about consciousness, perception, memory, and learning. The schema was not necessarily physical but provided a systematized way of thinking about the brain as a computer in some capacity. The methods of cognitive psychology, brain science, and machine learning would become entangled into present forms of truth regimes that blur lines between what is artificial and what is human consciousness.

In the creation of students through assumptions of mechanistic mind and learning theories a number of potential problems exist. A mechanistic perspective might include ways of thinking which are too reductive or simplistic, too focused on empirical evidence, or too reliant on quantitative over qualitative methods. Systems within institutions who take a mechanistic approach rely on a narrow view of assessments which homogenize thought through canned curricula and standardized testing creating hierarchies based on conformity over dissent. Dissent also plays a part in the problematics of mechanical focused institutions by the limiting of diverse perspectives narrowing the scope of what science "is" and who can be scientists. And again, this approach to mechanism of the student locks in certain dominate discourses about content and methods which neglect social and cultural factors. As a result, the mechanistic approach to science education can create hierarchies of students based on their ability to conform to a narrow view of science, perform well on standardized tests, and access expensive resources.

4.9 Understanding the Alchemy of Engineering Education: Challenges and Possibilities

Popkewitz's (2011) idea of alchemy highlights how engineering education is shaped by broader social and cultural factors, constantly adapting to changing social and historical conditions. It can also create hierarchies of value and reinforce existing power structures, leading to disparities by favoring certain forms of skill, knowledge, or expertise over others. For instance, engineering curricula that center around technical skills and knowledge, while neglecting areas such as ethics, social responsibility, and communication, may limit the view of who can practice engineering.

Alchemy provides a means of understanding the transformation and reinterpretation of educational ideas and practices over time. This process involves changes in academic and instructional language, methods of implementation, and underlying values and beliefs. In the context of engineering education, alchemy is particularly relevant as it seeks to transform students into skilled engineers who are valued by society. However, Popkewitz (2011) argues that advanced technology is often not necessary for engineering instruction and the student-engineer is the product of how educational standards, curricula, and teacher education programs center on various technologies and epistemologies.

Popkewitz argues that engineering education has historically served industrial and military needs. This has led to a focus on the practical application of technology to solve real-world problems rather than on theoretical or abstract concepts. The cultural and social values that prioritize rationality and efficiency also influence the way engineering is taught and practiced, potentially reinforcing gender and racial stereotypes that limit the transformative potential of education. Therefore, Popkewitz's idea of alchemy brings historical and anthropological ideas into the present-day classroom in order to understand the complex regimes of truths that impact the creation of engineers.

While some theorists support the current ways of teaching engineering, others want to see a more empirical and practical form of engineering to support students. Alternative theories of engineering education include desires for schools to become more technically focused, more open to the mobility of engineering principles across disciplines, and more authentic in the practice of solving real-world problems. However, these alternatives reflect underlying values of individualism, competition, and a focus on technical expertise rather than unbound creativity, critical thinking, and social responsibility.

Although common ground may be found in the way engineering education is taught in schools, there are unintended and obscured outcomes of curriculum design that Kirchgasler (in press) describes as "hauntings." The prospect of a singular set of scientific and technological understandings, combined with a stabilized method of curriculum development, creates opportunities for ways in which both understandings and objectives may not be universal, but rather products of dominant discourses. This complexity, coupled with Kirchgasler's (in press) approach to curriculum using Derrida's hauntology, raises questions about engineering education and engineering as a universalized method that is reapplied to its own dispersal as it progresses through time and space. Within curricula lie designs that organize and reorder individuals into categories of "abled" and "less-abled" through obscured normalization of developmental potentials, mental processes, and contemplations of eventualities. I propose this notion as a means of considering the influence of engineering on mechanized thought and design when engineering standards are reapplied. Kirchgasler (in press) argues that principles (for my use here, entities like efficiency, standardization, feedback loops, and surveillance) embody these hopes and fears and are used to infiltrate and create traits within those who can be considered "able," in this case, deemed trustworthy to navigate the future. While these principles are not explicit, they are a veiled component of the curriculum design process.

Popkewitz's concept of alchemy sheds light on the historical and cultural forces that shape engineering education and highlights the need for a more inclusive and diverse approach that values multiple forms of knowledge and expertise. However, as Kirchgasler (in press) argues, the current engineering curriculum design process may perpetuate hidden powers and reinforce stereotypes that limit the transformative potential of education. The concept of hauntology offers a lens to consider the unintended and obscured outcomes of curriculum design and the influence of engineering on mechanized thought and design. To ensure that engineering education promotes accurate forms of critical thinking, social responsibility, and unbound creativity, it is essential to question the underlying values and principles that inform curriculum design and to strive for a more equitable and inclusive educational system.

4.10 Engineering Education as a Tool for Reproducing Power Structures

Engineering education is a technology of disciplines that aims to mold students into the entity we call an engineer in society. However, narrow definitions of what an engineer is and who can be an engineer serve as gatekeepers that obscure the realities of racialized and genderdized interfaces within established and designed systems. Such a view reinforces dominant power structures and cultural values, perpetuating existing power structures and inequalities. One example of efforts to improve engineering education is the recognition that physics education needs to be more diverse and inclusive to meet the changing needs of the engineering workforce. There have been initiatives to increase participation in physics education, making it more accessible to underrepresented groups. However, this approach has limits, as it neglects practical skills and experience necessary for applying concepts associated with the real-world version of engineering.

The engineer is not engineered as a “creative” and “flexible” community-focused problem-solver. Rather, he or she is engineered as a continuation of power and influence perpetuating the discipline only by means of more engineering, technology, and a narrow form of practical science which neglects roots in cultural, overly complex, and the spiritually surreptitious. Educative technologies like curricula, instruments, pedagogies, standards, tests, and even toys design opportunities for producing the engineered engineer. This approach limits the ability of students to think critically about how science and technology can potentially operate in society and perpetuates existing power structures and inequalities.

Popkewitz (2012) argues that education is not neutral, but rather reflects specific cultural, political, and economic interests. In this way, the child is "engineered" to fit into a narrow worldview of science that serves secondary and tertiary interests of industry, economics, and the state seemingly at the will of a technoscientific social compact. Therefore, to create more inclusive engineering education, there is a need to challenge the dominant power structures and cultural values that perpetuate inequalities in the field.

Engineering is a practical discipline that applies scientific principles, particularly physics, to real-world problem-solving. To reproduce and instill engineering knowledge, educational methods have been designed to encourage students to think and act like engineers (Altman, 2012). The scientific method is a unifying idea that is used in engineering and other sciences to create knowledge. Dewey's ideas on scientific methodology and student interest have been vital in science education, as argued by Rudolph (2019). Educators have sought to integrate engineering concepts into the classroom by creating authentic experiences and project-based lessons that employ a Deweyan methodology, making the subject matter practical, relatable, and engaging.

In the early 20th century, engineering education programs began to shift away from focusing solely on mathematics and science skills. As noted by Ingalls (1924), advocates of engineering education programs recognized the importance of broader knowledge in economics, politics, and civil society, along with encouraging individual initiative and imagination. However, this broadening of engineering education did not come at the expense of technical skills as engineering practices and materials continued to be standardized during this time. According to Ingalls (1924), students pursuing an engineering education were expected to have superior intelligence, good health, and an aptitude for problem-solving, science, and mathematics. They were expected to embody scientific rationalities, and to become leaders of public service whose actions benefitted humankind.

This emphasis on engineering education also led to the integration of engineering practices into instructional and curriculum design, turning engineering education onto itself. As Tyack (1974) notes, engineering was seen as a way to "get politics out of schools" and hold school organizations to new standards. The focus on engineering design and outcomes provided a practical science-based ideology that informed arguments for efficiency and standardization in schools and education reform. Progressive administrators, influenced by professional management ideals similar to those which developed into Gribeauval's system and Taylorism, sought to apply scientific reasoning, trust in expertise, and engineering design concepts to education. This emphasis on standardization and accountability set bars for schools, students, teachers, and communities, reflecting the risk and reward associated with these entities. These developments had far-reaching consequences for engineering education and practice. While technical skills remained a priority, the inclusion of social and cultural knowledge broadened the understanding of what it meant to be an engineer. However, this broadening of engineering education also created certain ideals and standards that were often exclusionary.

4.11 Engineering the Child and the Engineered Engineer: Intersections of Reproduction and Disciplinary Power in Education and Engineering

The notion of "engineering the child" has been extensively debated in critical educational research, as discussed by Apple (1990). This concept pertains to how educational institutions and systems shape students' beliefs, values, and identities through a hidden curriculum that mirrors and reinforces existing power dynamics in society. In my exploration of the idea of the "engineered engineer," I am incorporating two distinct theoretical frameworks to demonstrate their intersection with each other in the context of reproduction, either as a structure or a superstructure, or in terms of disciplinary power. Examining the convergence of these theoretical frameworks can facilitate an understanding of the concept of the "engineered engineer" and rationalize unchecked progressivism.

The curriculum promotes specific forms of knowledge, skills, and attitudes while marginalizing or suppressing others, thus making education systems embedded in social and economic structures that reproduce inequalities. This concept of the "engineered child" in critical educational research can also be posited in Foucault's theory of the disciplinary society (Hoffman, 2014). According to Foucault, the disciplinary society operates through systems of discipline and control that regulate individuals' behavior and normalize them to conform to established norms and power structures. This power is enforced through institutions such as schools, prisons, and hospitals that exert control over individuals through surveillance and monitoring. Similarly, Lonsbury & Apple (2012) and McLaren & Giroux (2018) discuss the reproduction of power through structural considerations. Lastly, Popkewitz's (2012) concept aligns more closely with Foucault's in terms of power and the disciplinary nature of curricula and “modes of surveillance” or the encompassing of techniques used to monitor individuals or groups, including physical and digital means, by governments, organizations, or individuals.

The concept of engineering the child is complex, particularly when considering the "engineering of the engineer" and the potential pitfalls that entail. Lonsbury & Apple (2012) describe the goal of "educationalizing" the child, which refers to making them "acceptable" members of society. Similarly, McLaren & Giroux (2018) argue that education is a tool for social and cultural engineering and plays a key role in shaping the beliefs and values of individuals in society. Popkewitz (2008) refers to how education systems shape and mold children into a particular form of citizen based on a narrow worldview of science and technology. He argues that education systems are structured to produce a particular type of individual that is aligned with the dominant cultural and economic interests of society. As a result, the concept of "engineering the child" highlights the need for critical examination of the hidden curriculum or powers in education systems and the implications for reproducing existing power structures and perpetuating inequalities. Education is not neutral, and thus, there is a need to challenge the dominant power structures and cultural values that perpetuate inequalities in the field.

The concept of the "engineered engineer" is not a misstep in the historical and social context of engineering. Engineers have become a distinct entity shaped by the methods and standards established through their education and training. Societies with national interests have influenced ways of engineering, which carry with them implicit prescriptions about the world. Technoscientific knowledge based on limited conceptions of social progress has formed academic programs, curricula, and teaching methods to create physical and non-physical systems focused on societal fears, hopes, and desires. These programs and teaching technologies not only shape the engineer but also continue to reshape them through assessments, continuing education opportunities, revisiting and advancing technologies, and other forms of ongoing instruction.

While some of these methods may appear to emphasize individuality and personal commitment, much of it is regulated or demanded by engineering societies and employers. The process of "engineering the engineer" can be seen as an ongoing process of instructing, focused on developing and supporting individuals with the knowledge, skills, and commitment to design and build the systems and structures that shape the world (Hoffman, 2014; Lonsbury & Apple, 2012; McLaren & Giroux, 2018; Popkewitz, 2008).

In traditional engineering education, the focus is primarily on technical skills, which can create a barrier for some students who lack are deemed unable in the disciplines of science and mathematics. While assessments of technical skills are easily regulated, other traits such as collaboration, orderliness, and rule-following are also considered important for the exemplary engineer. However, these ideals may not fully consider the potential impact on others and are often appended to the curricula rather than integrated into the core of engineering education (Faulkner, 2001). Furthermore, ethics and equality are important considerations in engineering education, but they are often not given the same emphasis as technical skills. The influence of societal power relations and values on engineering education is significant and warrants attention (Slaughter & Rhoades, 2004).

Madhavan (2015) argues that the engineering mindset is characterized by flexibility, awareness, and grittiness. The engineer's problem-solving skills are centered on a vast knowledge base and involve working at the intersection of feasibility, viability, and desirability. The engineering mindset involves the ability to work from structural ideas and visualize structures through a combination of rules, models, and instincts. Engineers use models to base their advanced abstractions on reality before undertaking the task at hand. Feedback loops are essential in understanding and controlling tasks, allowing the engineer to adapt and maintain stability. However, Madhavan (2015) fails to explicitly discuss the sociopolitical and cultural impacts on the engineering mindset, which could affect the engineer's decision-making process.

Instead, Madhavan (2015) generically describes the importance of controlling tasks and the need for tradeoffs or judgments involving spectrums of possible solutions and alternatives. The modularity of making and adjusting the system creates complex and often unpredicted by-products based on changes to hit specific goals or achieve certain tasks. Engineers must set aside the recreation of specific systems in a "ground up" manner and focus on adapting a system to fit the goals of the moment. Engineers make design priorities and allocate resources by ferreting out the weak goals among stronger ones. While Madhavan's (2015) work provides a compelling overview of the engineering mindset as a systemic problem-solving capacity with high levels of fortitude and practicality, characterized by flexibility, awareness, and grittiness, it fails to focus on the importance of the expansion of the mind and mindset. To be equitable, the sociopolitical and cultural impacts on the engineering mindset should also be considered in order to create a more inclusive and socially responsible engineering education (Faulkner, 2001; Slaughter & Rhoades, 2004).

4.12 The Making of Ability and Dis-Ability

Engineering is founded on rationality, efficiency, and the desire for control over natural phenomena that are often considered unmanageable. Max Weber, a German sociologist, defined management as a practical and theoretical technology centered on rationality with the objective of achieving control, efficiency, and practicality (Weber, 1947). This is evident in the bureaucratization of control via hierarchies, positionalities, communications, and regulation. Control over natural phenomena includes not only the physical environment but also human bodies and behaviors. Weber's perspective provides a framework for considering engineers as individuals who are engineered themselves. The act of engineering is central to all rationality and offers enlightenment. This creates the potential to create the civilized from the savage, the rational from the irrational, and the abled from the "dis-abled."

Science education is a crucial component in producing individuals who are considered science-abled, but there are power and privilege dynamics at play that influence who is included in these fields. The concept of the science-(dis)abled body is closely related to the notion of the engineered non-engineer. Yolcu & Popkewitz (2019) argue that cultural and social influences play a significant role in shaping designations of ability and disability. They contend that these influences create categories of necessity and unnecessary attributes among the "abled," foregrounding particular attributes while marginalizing others. According to their argument, the body is a cultural production of a kind of person that has materiality in the real world, but it is not a pre-existing physical subject as such. Therefore, the body has no ontological status without materialized acts that constitute its reality. Such a status impacts individuals' experiences and how disciplinary practices can maintain social hierarchies and perpetuate inequalities. Moreover, this emphasis on technical rationality in education can obscure broader social and cultural forces that shape educational research and practice, perpetuating social inequalities (Foucault, 1975).

The significance of cultural and historical categorizations and rationalizations that normalize and pathologize ways of acting, being, and knowing is emphasized in this argument. The normalized "able" body is created through systematic design based on engineering methods, while the pathologized "disabled" body is rejected through the same system using engineering frameworks to advance the science-abled body. The material possibilities of bodies are too often connected to the practical and rational world of engineering, as per Foucault's idea that the body is an effect of the materiality of power. The engineering of children's worldview of science is demonstrated through constructs like STEM, 21st-century science skills, and the Next Generation Science Standards (NGSS), which prioritize specific types of knowledge and skills important in a globalized, technologically advanced world, creating a narrow definition of scientific literacy and technological proficiency.

4.13 STEM Education: A Historical Perspective and Sociopolitical Context

In 2015, the U.S. Congress passed the STEM Education Act, which defined STEM (Science, Technology, Engineering, and Mathematics) education as "a rigorous and interdisciplinary approach to learning and teaching the subjects of science, technology, engineering, and mathematics." It also authorized funding for STEM education programs and initiatives at the federal level. STEM education has emerged as a significant area of attention in educational policies and practices globally. To comprehend the current engineer's engineering, it is crucial to contemplate how the child has evolved into a subject of design and an exemplar of what it entails to be the "E" in STEM.

STEM is ubiquitous in educational institutions worldwide (Nerland & Jensen, 2019). Its impact on the sociopolitical realm in westernized and neocolonized[62] (Fanon, 1961) states has redefined much of what science education has looked like in the early part of the 21st century. To this point, my mentions of the STE assemblage has been an attempt to transport some of the ideas of STEM through space and time providing differing sociopolitical and cultural context. As the focus switches to a present version of STEM, it is important to bring in the "M" of STEM. The "M" stands for mathematics and in itself offers a complex trajectory through the same time and space. While keeping centered on engineering, mathematics would have added a layer of complexity which is very important, but not central to this work at this time. Mathematics as the "language" of STEM has been discussed in this work in a very superficial way through terms like quantification, measurements, and computations. It is vital to all considerations of science whether they be the physical sciences and engineering, or they be the social sciences like psychology and sociology. Mathematics can provide a more grounded way to think about engineering. While I plan to delve into this topic in future works, at present, I aim to introduce mathematics into the conversation surrounding the assemblage of science, technology, and engineering, and also the current sociopolitical environment that has led to the emergence of STEM and STEM education in the Westernized world.

STEM has become a way of branding the aforementioned STE assemblage referenced throughout this dissertation. Because of this, one might realize the defining of the separate disciplines have remained relatively stable while contextually STEM has taken on a role of

[62] "Neocolonized" refers to the process of a country or region being subjected to a form of colonization or exploitation by another country or region, often in a less overt or direct manner than traditional colonialism. It can involve economic or cultural domination, as well as political control, and can result in the loss of autonomy and agency for the neocolonized population.

perceived progression throughout historical time and space. Of course, this is inaccurate in some ways and accurate in others. Ancient civilizations throughout the world utilized early principles of mathematics, physics, and engineering to advance ideas and to benefit parts of early societies. As new ways of knowing replaced religious strife and demystification in the Renaissance and the Enlightenment eras, the rationality of science would begin to influence westernized societies attitudes. Scientists like Galileo, Newton, and Boyle[63] would establish, enact, and represent particular combinations of science, technologies, engineering, and mathematics in ways which would sway sociopolitical leaders and progress seeking populaces. Having gained levels of social and political power and a progressive conviction, an early iteration of STEM would enter the Industrial Revolution and the early 20th century as a vital entity to the advancement of society by means of a technoscientific union of engineering, society, and production.

Economic progress for and from the production of industrialization would invigorate attitudes towards early STEM-like programs in education. The creation for workers in this early iteration of STEM became a matter of importance in the economic advancement of Westernized nations. The need for such programs led to the creation of new educational initiatives within traditional institutions and played a crucial role in the establishment of technical schools and vocational training centers.

[63] Galileo (1564-1642) was an Italian astronomer and physicist who developed the telescope and made significant observations of the moon, planets, and stars, which challenged the Aristotelian view of the cosmos. Newton (1642-1727) was an English physicist and mathematician who developed the laws of motion and universal gravitation and is considered one of the most influential scientists of all time. Boyle (1627-1691) was an Irish chemist and physicist who is known for his work on gases, particularly Boyle's law, which describes the relationship between the pressure and volume of a gas. These figures and their work contributed to the shift towards empirical and mathematical approaches to understanding the natural world, and their ideas and methods had significant social and cultural impacts on the development of science and society in the centuries that followed.

Today, many schools have adopted STEM-focused curricula and are making efforts to expand access to underrepresented groups. However, there has been a recent shift back towards economic needs, ideals of American exceptionalism, and a recognition of the importance of science, technology, and engineering to progress. This has led to the rebranding of the STEM concept as a form of technoscientific assertion and redemption. The evolution of STEM education is influenced by various historical, societal, and technological factors that shape the need to prepare students for the modern workforce. STEM education is viewed as significantly important through a contemporary technoscientific perspective, owing to its crucial role in economic growth, national security, and the global workforce. STEM fields are professed to act as drivers of economic growth and innovation, with STEM professionals' technological advancements and scientific discoveries contributing to the creation of new industries, products, and services that enhance the standard of living and foster economic development. Additionally, STEM fields are deemed critical to national security, as the development of new defense technologies, cybersecurity measures, and intelligence gathering necessitates STEM skills and expertise. But despite these beliefs, a number of problematics arise when we consider STEM as vital to the progress of a nation.

4.14 The Dominance of STEM, the Next Generation Science Standards, and 21st Century Science Skills

STEM fields have been traditionally dominated by white males (Griffin et al., 2016; McGee & Labaree, 2015; McCabe et al., 2016). As a result, dominant views of scientists and what counts as science have developed over time and space narrowing perceptions of progress, values, problems, and solutions. The dominant view also shapes rationalities, methodologies, and standards. In addition to the marginalization of individuals based in racialized and genderdized attitudes, the narrow focus of technical skills in STEM sometimes marginalizes individuals prone to areas like the arts, humanities, or social sciences. As I analyze STEM and its educational compliments, the Next Generation Science Standards (NGSS), and 21st-century science skills, I will expand on these critiques and the ways in which STEM as a part of a regime of truth makes types of people. In this case it makes, or engineers, engineers and non-engineers.

STEM, the NGSS, and 21st-century science skills are interrelated and, as a dominate assemblage of discourses and technologies in science education in the present, allow for an analysis of how the ways science is presented reflect certain assumptions related to the control of the body, mind, and soul. STEM education exists as a way to discipline students with regards to problem-solving skills in the fields of science, technology, engineering, and mathematics. The NGSS provides the standards and expectations for science learning with STEM ideals central to their design. They claim to offer a more integrated and interdisciplinary approach to science education, with a focus on developing students' scientific literacy and inquiry skills through hands-on learning and a more rigorous approach to understanding of core scientific concepts, methods, and principles. But again, this begs to question exactly which concepts, methods, and principles are of interest in these standards.

Similar questions arise around the 21st-century science skills. Many of the NGSS performance expectations are aligned with these skills including critical thinking, problem-solving, collaboration, and communication. While the 21st-century science skills go beyond the narrow view of science in the form of technical knowledge and focus on the active side of science, it too has a narrow focus. This includes the disciplining of ways to think, observe, communicate, and problem-solve. For better or for worse, the NGSS and STEM education are both closely aligned with the development of 21st-century science skills. Despite the fact that these three concepts condense the knowledge and methodologies of science into narrow fields, STEM, the NGSS, and the 21st Century Science Skills set the standards for science education in a vast number of schools across the United States and globally.

STEM, 21st Century Science Skills, and the Next Generation Science Standards (NGSS) can be thought of as an assemblage of truths in the sense that they represent a complex, interconnected network of ideas, practices, and institutions that shape our understanding of what it means to learn, teach, and do science in the 21st century. The STEM assemblage (as I will refer to the present-day STE assemblage with mathematics added and includes components of the NGSS and 21st Century Science Skills as they relate to the functionality of STEM as an educational technology). While this STEM assemblage offers a vast number of ways to analyze dominant forms of science education in the present, for this dissertation, I am interested in the ways in which this entity influences engineering, the design of science and engineering education, and the engineered engineer as a modern product of science, sociopolitics, biopower, and universalism.

4.15 STEM and Biopower: The Power of the STEM Assemblage

In this analysis, extensive use was made of Rabinow & Rose's (2006) work on biopower to examine how knowledge is situated within specific historical and cultural contexts over time and space. To avoid oversimplified arguments, the main idea was employed, which permits certain temporal and spatial powers to merge into the STEM assemblage, engineering, and the engineer, while recognizing STEM education as a complex entity inextricably intertwined with broader social and political processes. According to Rabinow & Rose (2006), knowledge and power are intricately interwoven, and scientific knowledge is frequently exploited to legitimize particular forms of social and political organization and control. From this viewpoint, STEM and STEM education, as well as the cultural and historical context presented in earlier chapters, should be interpreted and analyzed as political endeavors connected to modes of thinking and existing in the context of diverse social and political desires and insecurities.

Throughout this work, the concept of biopower, originally introduced by Foucault (1975), is employed to describe a type of power that operates through biological knowledge and techniques to control individuals and populations. Rabinow & Rose (2003) extend Foucault's notion of biopower by highlighting its impact on the body, mind, and soul. Their definition explains how biopower functions to control human beings by subjecting them to biological processes, which in turn creates them as objects of knowledge and control. This control is exerted through various practices, technologies, and institutions that manage and regulate the health, welfare, and behavior of populations. To separate the subject from the objectified, Rabinow & Rose (2006) introduce the concept of the plane of actuality.

According to Rabinow and Rose (2006), the plane of actuality is a dynamic way to analyze and navigate the complex system of power relationships in which biopower operates. It is where power is made visible and tangible, and where resistance and contestation can occur. The plane of actuality consists of three levels: empirical, ontological, and ethical. The empirical level relates to observable and measurable facts and data derived from entities like scientific experiments or market research, while the ontological level concerns the underlying structures and assumptions about reality, such as cultural beliefs or philosophical theories. Lastly, the ethical level deals with the values and moral considerations that guide our decisions and actions, including issues related to social justice or environmental sustainability.

The first condition of biopower on the plane of actuality involves the creation of authoritative discourses that define the vital nature of human life. These discourses are created by formal organizations, institutions, and structures that have the power to regulate behavior and enforce rules and standards of what is acceptable or unacceptable in a given context. These rules and standards are referred to as norms and are considered essential for the functioning of society. In STEM, we observe a system of truths that are propagated and transmitted through various individuals and institutions, including politicians, scientists, educators, statisticians, futurists, psychologists, and society at large. These truths pertain to the behaviors and actions of individuals and are based on communal needs, such as the demand for STEM professionals and the cultivation of rational thinking in scientific approaches and responsible citizenship.

The second condition of biopower on the plane of actuality calls for interventions of the collective in the name of futures, salvation, and discourses. These interventions are often perceived as helpful or ethical but carry with them consequences of othering, superiority, and deficit constructs. These entities shape how we understand and talk about the world, including scientific theories, cultural beliefs, and political ideologies. These entities acting as non-material technologies, also influence and control by creating ways of legitimizing knowledge and creating belief systems. In STEM, interventions based on STEM often focus on goals such as promoting scientific progress, maintaining economic stability, and fostering national pride.

The third condition of biopower on the plane of actuality involves the ways in which individuals are constructed as subjects of power. This involves being exposed to and internalizing certain forms of authority and truth discourses, which shape practices of the self. In STEM, this condition of biopower includes the ways in which the STEM assemblage is utilized and how it shapes individuals as subjects of power. It is shaped by a range of factors, including socialization, education, media, and cultural influences. It is also shaped by the technologies and institutions of power that operate on the plane of actuality, as well as by the resistance and contestation that can arise in response to those power relations.

This analysis highlights the intricate interplay between STEM and biopower, showing how scientific knowledge and technological advancements can be used to shape and control individuals and populations. The concept of the plane of actuality introduced provides a dynamic framework to analyze the complex system of power relationships in which biopower operates. By examining the three conditions of biopower on the plane of actuality, we can better understand how the STEM assemblage is utilized to shape individuals as subjects of power. This work emphasizes the need for critical analysis and resistance to the dominant discourses and interventions of STEM education and its broader social and political processes. The power of the STEM assemblage should be recognized, but also scrutinized and questioned in order to work towards a more just and equitable society.

4.16 Science and Knowledge Systems

STEM education is widely accepted and valued due to its perceived impartiality and solid epistemological foundation. However, the dominant view of science, technology, engineering, and mathematics as a narrow and trusted set of knowledges and methods often prioritizes Westernized scientific knowledge, marginalizing other forms of knowledge and ways of knowing. This perpetuates a globalized worldview that reinforces existing power structures and privileges Westernized ways of thinking. Critics such as Edward Said argue that this emphasis on Westernized science reinforces a sense of superiority and dominance, overlooking the cultural and historical factors that shape our understanding of the world. This narrow view of scientific knowledge and methods is deeply embedded in STEM education and creates limited and biased ways of thinking, reducing knowledge to rote memorization and ranking individuals based on standardized measures.

There are various critiques of the traditional view of scientific knowledge as an objective and universal truth. The emphasis on scientific objectivity and neutrality in STEM often masks the ways in which scientific knowledge and practices are influenced by other cultural, political, and historical factors, and may perpetuate biases and stereotypes. Apple (2013) argues that STEM and science are influenced by cultural, political, and historical factors that often perpetuate biases and stereotypes. Similarly, Harding (2016) asserts that scientific knowledge is shaped by the larger social context in which it is produced and often reflects the values and assumptions of the dominant culture. Harding (2016) advocates for a "feminist standpoint" approach to science that recognizes the importance of diverse perspectives and experiences in producing relevant and inclusive knowledge. By centering the experiences and perspectives of marginalized groups, a feminist standpoint approach can uncover hidden biases and assumptions in scientific research and generate new insights and understandings.

According to Foucault (1973), scientific knowledge is shaped by complex power relations that determine what can be known and who has the authority to produce knowledge. Haraway (2004) expands on this idea by advocating for a "situated knowledge" approach to science that recognizes the influence of the researcher's social and historical context in shaping scientific knowledge. By acknowledging the role of power dynamics and social context in scientific knowledge production, both Foucault (1973) and Haraway (2004) call for a more nuanced and critical approach to the understanding of scientific knowledge.

Latour (1989) challenges the notion of scientific objectivity as a "myth" and instead, asserts that science is always influenced by its social and political context. He critiques the ways in which scientific knowledge reinforces power structures and advocates for a more collaborative approach to science that incorporates diverse perspectives and stakeholders. Additionally, Latour (1987) argues against the idea of a fixed, universal nature that exists independent of human intervention, promoting instead a more relational and network-oriented approach to science and technology.

Popkewitz (2012) argues for a more democratic and participatory approach to education, one that involves a diversity of stakeholders in the educational process and that recognizes the importance of local knowledge and context. In his book, "Cosmopolitanism and the Age of School Reform," Popkewitz critiques the globalized approach to STEM education, which he argues prioritizes technological advancement and economic competitiveness over local cultural and social contexts. Similarly, Mohanty's (1984) work on postcolonial feminism highlights how colonialism and imperialism continue to shape knowledge production and power relations in Westernized societies, and critiques Western feminism for reinforcing colonial power dynamics. She argues for a more inclusive and diverse approach to feminist scholarship.

Furthermore, Kirchgasler (2019) argues the assumption that NGSS links students' interest in science and achievement. She contends it perpetuates the idea that certain groups are less interested. The NGSS case studies categorize students based on their interests, with "gifted and talented" students having fully developed scientific interests, and girls and non-dominant groups having interests that can be used to spark an interest in science. However, Kirchgasler (2019) warns that such depictions can lead to labeling and create more inequities.

Lastly, STEM education emphasizes analytical thinking, but creativity is also crucial for developing innovative solutions to complex problems. However, the mechanistic approach to STEM can create a hierarchy based on memorization and recitation of information rather than creative and critical thinking. Moreover, creativity in STEM is often limited by the need to adhere to scientific principles and laws, which can narrow the range of potential ideas. Deborah Ball has criticized the narrow focus on technical skills in STEM education, arguing that it may neglect critical thinking and collaboration. Yong-Yi (2022) has argued that this approach overlooks the importance of developing creativity and innovation skills. Additionally, cultural and social norms can influence creativity, potentially limiting the range of acceptable ideas, while bias and a lack of diversity can stifle innovative thinking in STEM fields.

Although this chapter is primarily focused on the operation of power, particularly Rabinow & Rose's (2003) concept of biopower in STEM education, it's crucial to acknowledge the existence of smaller power relations within the field. STEM reinforces a binary between engineers and non-engineers, which reinforces social hierarchies rooted in privileged knowledge and expertise. Critics argue that the STEM framework presents a narrow view of science that prioritizes a positivist and reductionist approach to understanding the natural world and giving preference to technical skills over more holistic approaches. This can lead to oversimplification of complex scientific issues and disregard for the social, cultural, and historical contexts in which scientific knowledge is produced and applied.

In addition, the universalistic view of science presented in STEM supports the notion that scientific knowledge is objective, value-free, and applicable across different cultures and contexts. This ignores the social construction of scientific knowledge and the potential for it to reflect the interests and biases of specific groups and institutions. Critics argue that this universalization of science contributes to a dominant globalized worldview that erases the diversity of scientific knowledge and ways of knowing across cultures and regions. Therefore, a more comprehensive view of science education is required, one that acknowledges the social, cultural, and historical contexts in which scientific knowledge is produced and applied, and that includes alternative perspectives on science.

4.17 The Limits of Technological Solutions: Critiquing STEM Education's Technoscientific View of the World

The assemblage of STEM and the trust in science, engineering, and technology have the potential to standardize problem-solving approaches, shape individual identities in technoscientific domains, and create new boundaries between the material and non-material, influenced by information and consumerism. However, this approach can resemble the reduction of science knowledge and methods to westernized forms of rationality and critical thinking, similar to how technological determinism assumes that progress is always positive and limits solution formation in STEM and engineering education.

Critics argue that focusing solely on technological solutions can ignore the social and ethical implications of technological development, restricting opportunities for critical reflection on technology's societal role. For instance, a narrow emphasis on technology to tackle global issues, such as climate change or energy sustainability, without addressing underlying social and economic factors, can reinforce a dominant globalized view reliant on technology as a solution rather than addressing the root causes. Popkewitz, et al. (2020) propose that relying on rational technological solutions confines changes within technologized systems by presuming problem-solving based solely on a linear cause-and-effect relationship between inputs and outputs. This approach disregards the social, cultural, and political factors that shape scientific knowledge and innovation, lacking emphasis on real-world applications in a technoscientific society, thus potentially marginalizing other essential forms of knowledge required to tackle environmental and social issues. Similarly, Shiva (1993) has criticized the idea of "monocultures of the mind," prioritizing narrow forms of scientific and technological knowledge while overlooking diverse cultural and ecological knowledge systems.

Finally, technological discrimination refers to technology's use in ways that discriminate against certain groups based on factors such as race, gender, or socioeconomic status. While innovation involves creating new solutions to existing problems, which can be either incremental or disruptive, and real-world applications refer to the practical usage of technology and innovation, influenced by regulatory frameworks, market demand, and social norms. The combination of technological speed and scope has raised concerns among critics of STEM education and technoscientific entities. They caution that unregulated development and use of technology may reinforce existing power structures and further marginalize disadvantaged groups.

Noble (2018) has highlighted the perpetuation of racial and gender biases by search engines and algorithms. He calls for greater transparency and accountability in their development and use. The overreliance on technology in STEM education can also lead to a deficit model of learning and reinforce existing social and economic inequalities. Students may be reduced to mere numbers or rubrics, and the focus may shift towards a standardized form of rote learning and memorization instead of critical thinking and problem-solving.

Moreover, the technoscientific view of the world that STEM education promotes is problematic because it positions technology as the ultimate solution to societal problems. This trust in technology as a universal solution neglects the underlying social, economic, and political structures that contribute to these problems. This approach may lead to the implementation of technological solutions without considering their broader implications. Barad (2007) argues that the boundaries between human and non-human are not fixed, but rather constantly renegotiated through practices of measurement, observation, and experimentation, which actively produce reality rather than simply reflecting it. The rapid advancement and integration of technology in STEM education and society at large demands greater critical reflection on the social and ethical implications of technological development. The technoscientific view of the world should be balanced with an understanding of the underlying intrusions and surveillances.

STEM is inextricably linked to economic and industrial progress, reflecting the fundamental elements that are deemed vital by advanced capitalist nations. However, there are concerns about the power dynamics created by market-driven models of education and knowledge production, as highlighted by Giroux (2008), as well as ethical and equity-related questions. STEM education can prioritize the interests of corporations and governments at the expense of the needs of students and society, as noted by Bauman (2000). Popkewitz's (2009) analysis of NGSS indicates that the standards themselves are influenced by broader social, economic, and political forces that perpetuate power imbalances and inequalities among different nations and cultures, leading to the marginalization of certain ways of knowing and privileging of others. Additionally, technologies that are imposed as acts of empowerment or salvation can potentially transform into technologies of change, discipline, and surveillance, as discussed by Ames (2009).

The integration of technology in STEM education and society at large has created a need for greater critical reflection on the social and ethical implications of technological development. While STEM education can standardize problem-solving approaches, shape individual identities, and create new boundaries between the material and non-material, its over-reliance on technological solutions can overlook the social and ethical implications of technological development, reinforcing existing power structures and marginalizing disadvantaged groups. Furthermore, the trust in technology as a universal solution neglects the underlying social, economic, and political structures that contribute to societal problems. Therefore, a pluralistic approach to STEM education that values diversity and promotes critical thinking and cultural exchange is recommended to balance the technoscientific view of the world with an understanding of the underlying social, economic, and political structures that shape it. It is essential to develop a more holistic and inclusive approach to STEM education that reflects the broader social and cultural contexts in which technological innovation and development occur.

4.18 Nature of STEM Skills and the Need for a Nuanced Approach

Similar to the cultivation of knowledge involved in the creation of the STEM assemblage, science skills have been amassed into a kind of skills framework composed mainly of 20th century skills but has the potential to expand under particular outside pressures. And just as with the cultivation of knowledge, the cultivation of skills involves analogous power relations effecting the ways in which skills are defined and valued. Like STEM related knowledges, skills frameworks are often shaped by dominant social and cultural norms, and that they can marginalize or exclude certain groups or forms of knowledge. Here, the emphasis on individuality and the marginalization of the abject tends to ignore the idea that skills are co-constructed through social interactions and relationships and that individual skills cannot be divorced from social and cultural contexts.

The assumption that a universally applicable set of skills based on 20th Century Science Skills and the STEM framework exists is contradicted by the idea that these skills are permanently fixed once learned. This assumption is challenged by Hacking's (1983) analysis of the concept of "observation" in experimental physics in his book "Representing and Intervening." Hacking (1983) demonstrates that the meaning and use of observation changed over time with the evolution of scientific theories and experimental techniques, revealing the dynamic nature of scientific knowledge. Therefore, the notion that STEM and science skills are universally applicable or stable entities within science is problematic. As a result, STEM students must be flexible and open to acquiring new skills and techniques,

This is further emphasized by a number of critics. Pickering (1995) calls for a more critical and self-reflective approach to scientific knowledge and skill production, acknowledging the role of power in scientific practice and the contributions of both material and non-material elements. Moreover, Barad's (2007) concept of "agential realism" further challenges the notion of a universal set of stable skills underlying the 20th Century Science Skills and the STEM assemblage. Agential realism underscores the significance of materiality and embodiment in knowledge production and highlights the role of agency and contingency in shaping scientific knowledge. It contests the idea that science skills are fixed technical competencies and emphasizes the importance of considering the broader social, cultural, and historical contexts in which scientific knowledge is created and applied.

In some iterations of the STEM assemblage, content knowledges become secondary to the skills work. Some of the focus of STEM skills seem to relate more to science than others. For example, while skill development focused on critical thinking, problem-solving, and technical skills have plausible connections to science, others skills form around influences less bound to scientific rationalities and more about creating kinds of people related to the work of science. Such skills are summed up by "vocational manuals" and "career guides" which seep into STEM education through the teachings and expectations of things like creativity, curiosity and wonder, attention to detail, precision, and time management skills.

The development of skills related to persistence, individualism, and courage has become increasingly prominent in STEM education. These skills have been packaged into modern initiatives and buzzwords such as "growth mindset" and "grit." Dweck (2006) and Duckworth (2016) popularized these concepts. The notion of a "growth mindset" asserts that intelligence and abilities can be developed through hard work and perseverance, whereas a fixed mindset views them as innate and unalterable. "Grit" is characterized by a combination of passion and determination to achieve long-term goals, entailing an unwavering commitment to one's objectives despite setbacks and obstacles.

The concepts of "grit" and "mindset" in STEM education have been criticized by scholars such as Ladson-Billings (2009), Kumashiro (2010), Tuhiwai Smith & Tuck (2012), and Kirchgasler (2018) due to their cultural biases and potential to perpetuate systemic inequalities. These concepts may not be relevant or applicable to students from different cultural backgrounds and may prioritize traits and behaviors valued in Westernized, individualistic cultures. This can create a "blame the victim" mentality that fails to address structural issues that hinder success in STEM fields.

Furthermore, an overemphasis on "grit" and "mindset" in STEM education may oversimplify the complex factors that contribute to success, particularly in STEM fields. Kirchgasler (2018) argues that "grit" has been operationalized as a scientific object and pedagogical tool, leading to a narrow focus on individual traits rather than broader social and cultural factors. Additionally, different cultures may prioritize teamwork and collaboration over individual achievement, highlighting the need for a more nuanced and culturally responsive approach to STEM education. Concepts like "grit" and "growth mindset" can oversimplify the multifaceted factors that contribute to success in STEM fields. Moreover, mechanical teaching methods that prioritize memorization and following predetermined procedures can limit the development of deeper conceptual understanding and critical thinking skills. This approach is often viewed as a linear, surface-level process, rather than promoting a more nuanced and holistic approach to learning and problem-solving (Kohn, 2015; Ball, 2021).

4.19 Critiques and Challenges to Social Skills and Diversity in STEM Education

Social skills are often deemed crucial in STEM education (Capraro et al., 2013). The STEM environment combines collaboration and individualism through suggested practices in the classroom, drawing from the original educational theories of Dewey and Vygotsky. However, classrooms, group dynamics, and individuals are complex, and dominant voices and exemplary students often control or are encouraged to control group learning, even in seemingly collaborative and equitable environments. Ahmed (2012) argues that scientific knowledge can reinforce dominant social norms and perpetuate power structures, creating marginalization for certain groups. Serres (1995) also critiques the hierarchical construction of knowledge, which prioritizes individual achievement over collaboration and teamwork.

Furthermore, the competitive nature built into STEM education can lead to a focus on individual achievement and competition over collaboration and community-based problem-solving, reinforcing a neoliberal or globalized worldview. Keller (1995) advocates for more authentic collaboration to foster inclusivity in STEM education. Popkewitz (2009) criticizes the prioritization of 21st-century skills in education, arguing that it reflects a neoliberal agenda that prioritizes economic competitiveness over critical thinking and democratic citizenship. This focus on skills and competencies ignores deeper questions about education's purpose and meaning, failing to address the structural inequalities contributing to educational disparities.

Finally, a critical aspect of STEM education is the acceptance of diversity. The persistent lack of representation of women, people of color, and other marginalized groups in STEM education and STEM fields hinders creativity and innovation and perpetuates inequalities. The issue of diversity in STEM is rooted in social justice, power dynamics, and colonization, including matters of identity, language, and cultural predispositions. Crenshaw (2017) uses the concept of "intersectionality" to explain how different forms of oppression intersect and exacerbate inequality. She identifies systemic barriers as a key factor behind the underrepresentation of women and people of color in STEM fields. Similarly, Spivak (2004) criticizes the connection between knowledge construction and colonialism and imperialism and advocates for recognizing the historical and political contexts of knowledge creation and working to decolonize education.

Critiques by Derrida (1970) and bell hooks (2000) challenge the assumption that language and meaning in scientific inquiry are objective and transparent. Derrida argues that language is always situated within social and historical contexts, and meaning is subject to interpretation, while hooks (1994) emphasizes acknowledging power dynamics and creating inclusive and equitable learning environments. This requires a fundamental shift in how we view knowledge and expertise and recognizing that scientific knowledge is always situated within social and cultural contexts. The lack of diversity in STEM education reinforces traditional power structures and marginalizes underrepresented groups. There is a need to reimagine STEM education to be more inclusive, equitable, and promote critical thinking and social justice. These critiques apply to the entire field of STEM education, including NGSS, 21st-century skills, and related concepts and frameworks.

4.20 Conclusion

"Engineering the engineer" is a concept that has gained increasing attention in recent years as a means of addressing the narrow focus on technical skills in engineering education and practice. This narrow focus has led to the marginalization of certain groups and created a stereotypical mold of the "ideal" engineer, which excludes those who do not conform to this mold. To address this issue, there is a growing need to recognize and value diverse skills and perspectives that individuals can bring to the field.

Creating a more equitable and diverse field requires a shift in the culture of engineering education and practice towards a more holistic view of what it means to be an engineer. This means moving away from the narrow focus on technical skills and embracing a more inclusive view of what constitutes valuable skills in the field. It also means turning the engineering system back on itself, so that the very systems and ideas that led to the creation of the engineer are now responsible for engineering the engineer themselves.

However, there is a prevailing mindset among engineers that extends beyond the mere implementation of tools and techniques. Students are taught not only about methods and techniques but also about moral values and ways of being. Thus, the concept of "engineering" encompasses more of a mindset and problem-solving approach rather than a narrow professional or disciplinary field. Engineering is not an action or a thought, but a program of consciousness.

Ultimately, the goal of "engineering the engineer" should be to create a more equitable and diverse field that recognizes and values the unique skills and perspectives that different individuals can bring. By doing so, we can create a field that is more inclusive, diverse, and better equipped to address the complex challenges of our time. This requires a willingness to reflect on and strengthen the idea of the engineer, and to integrate cultural diversity into the foundational structures, systems, and analysis of the discipline. As the field of engineering continues to spread into many different disciplines, from software development to product design, it is essential to consider anyone who applies engineering principles and methods to problem-solving to be an engineer, regardless of their specific background or training. With this broad understanding of what it means to be an engineer, we can create a more inclusive and diverse field that is better equipped to address the complex challenges of our time.

Chapter 5: The Engineered

5.1 The Engineered

This dissertation extends both an invitation to ponder and an invitation to take action. By that I mean I hope the thoughts here are provoking and encouraging. And it has been a very personal experience. However, Grammarly, the writing help application, has admonished me throughout for my use of "I" and "my" throughout the process of editing. While the messages of condemning "personalized" began to shape the end product, I realized I was working within a framework that parallels some of my critique here. In my younger days, it was a push back against authority. Now it is called deconstruction and analysis. Either way, I question the rules that make one shape words with the goal of hiding themselves behind the experiences and ideas of what is probably their first and possibly only seminal work. Seldom does a well-structured product have heart and soul. The structure of writing has been modified for Artificial Intelligence (AI) applications which, I will admit, are extremely helpful. However, the construction of outputs still lacks a certain je ne sais quoi. While fears of AI often focus on the ways in which the entity becomes more able to act like the human, I fear that through the binding of thoughts and methods, we have met it at least part way. With that, I offer a brief and personal vignette which, no doubt, runs contrary to the guidance of Grammarly.

In 1982 I was a 6th grade hockey fan in the state of New Jersey. Though I would never give up my alliance to my New York team, I was excited to welcome the New Jersey Devils to the Garden State. I remember fondly of writing a program in my BASIC Language computer class which created the Devils logo on the computer screen. After hours of commanding the outcome in which I was interested, I finally achieved my goal. Not only did the logo look as good as it could on the computer I was using at the time, but as the pixels illuminated the logo on the screen, the eye could follow certain deliberate patterns which, in my 6th grade mind, made for a dramatic presentation. It was, in my young mind, perfection. However, the grade of a “C” I received for my effort said different. And so was born a life-long critical mind.

Turkle and Papert's (1990) book, "Epistemological Pluralism: Styles and Voices Within the Computer Culture,” had a profound impact on my perspective during my sixth-grade years, and its influence continues to shape my current outlook towards science and technology. The authors advocate for recognizing and embracing diverse epistemological styles and approaches, asserting that the world can be understood through various lenses. They also note that the computer science culture often emphasizes rational and analytical thinking to the exclusion of other equally valuable styles of thinking. As such, they argue for a need to appreciate and value these alternative styles within the culture.

Turkle and Papert (1990) propose that the computer science culture encompasses various voices, such as those of engineers, hackers, artists, and educators, and these diverse perspectives should be celebrated and encouraged. They suggest creating spaces where these voices can converge and collaborate, exemplified in the form of the bricoleur programmer. The authors argue that this approach offers a different way of thinking about educational approaches in computer science.

The authors also discuss the engineering-like programmer, who works within a rule-driven system and finds excitement in mastering it in a top-down, divide-and-conquer way. This structured "planner's" approach, taught in the Harvard programming course, is endorsed by both the industry and the academy, and it involves dissecting a programming problem into separate parts and designing modular solutions to fit them into an intended whole. While some programmers adhere to this approach due to external pressures from their teachers or employers, others prefer it, finding it natural to plan, divide the task, and use modules and sub procedures.

The structured programming approach, according to Turkle and Papert (1990, p. 7), contrasts with the bricoleur programmer who is less interested in the programming structure and instead enjoys "playing" with the program's elements "as though they were material elements." While hierarchy and abstraction are valued by the structured programmer's "planner's" aesthetic, the bricoleur programmer, like Levi-Strauss's bricoleur scientists, prefers negotiating and rearranging their materials.

The authors draw a comparison between the bricoleur programmer and a painter who steps back between brushstrokes, contemplates the canvas, and decides what to do next. Bricoleurs utilize a mastery of associations and interactions, and they navigate midcourse corrections when they make mistakes. Unlike planners, who see a program as an instrument for premeditated control, bricoleurs set out to achieve their goals in the spirit of a collaborative venture with the machine. For planners, getting a program to work is akin to "saying one's piece," while for bricoleurs, it's more of a conversation than a monologue.

Turkle & Papert (1990) present Alex and Anne as students who deviate from conventional programming approaches, and their work serves as a prime example of the bricoleur archetype.

In building a mobile robot using Lego building blocks, Alex chooses to forego the conventional wheel-motor apparatus as a means of movement. Instead, he repurposes the wheels as flat disks, using the vibrations from the engaged motor to create movement. This unconventional approach is characteristic of the bricoleur's preference for negotiation and rearrangement of materials, rather than adhering to pre-established structures.

When Alex encounters the Logo: Turtle Icon Programming system, he again resists the normative programming practices of using sub-procedures to organize commands. Instead, he prioritizes the aesthetic presentation of his program on the screen over the final output. Though his approach may be less efficient and precise, Alex's work exemplifies the bricoleur's focus on means over ends and the negotiation of materials to achieve a desired outcome. Turkle & Papert (1990) conclude that Alex's work challenges the notion that the general or abstract is always superior to the specific or concrete. In essence, Alex's approach represents a series of negotiations that emphasize the sensory experience of programming, much like a chef who creates flavors, colors, and aromas from the soul, without strictly adhering to a recipe.

Anne, like Alex, also takes a bricoleur approach to technical knowledge. Instead of starting with a structural design, she enjoys manipulating angles, shapes, rates, and coordinates to let effects emerge. Turkle and Papert (1990) compare Anne's approach to that of a writer who doesn't use an outline but instead starts with one idea, associates it with another, and finds a connection with a third. They note that the resulting essay can be just as elegant and easy to read as one filled in from an outline. Similarly, the final program produced by a bricoleur like Anne can be just as organized and elegant as one created with a top-down approach.

In contrast, structured programmers tend to feel uncomfortable with a construct until it is thoroughly black-boxed, with all traces of the potentially messy process of construction hidden from view. They may derive a sense of power from using black-boxed programs, as others can use them exactly as they are to create new digital tools.

To expand our understanding of engineering and its potential, it is necessary to challenge the borders of modern technoscientific perspectives and question certain assumptions. Engineers have traditionally been viewed as the primary drivers of innovation and progress, yet the ideas of the bricoleur provide a valuable alternative approach to problem-solving and creativity. While the structured methods of the engineer offer efficiency and reliability, the bricoleur's ability to improvise and work with available resources can lead to unique and unexpected solutions. By integrating both approaches, we can foster a more comprehensive and adaptable approach to innovation, leveraging the strengths of each to achieve better outcomes. Therefore, it is essential to consider the insights of both the engineer and the bricoleur to cultivate a more holistic perspective on engineering and its potential impact.

5.2 Engineering the Mechanical Mind and Soul: Ethical, Philosophical, and Historical Implications

The concept of engineering the mechanical mind and soul is relevant in the present as it involves using mechanical technologies and algorithms to control and manipulate human bodies, minds, and souls, which raises ethical, philosophical, and historical questions. The tension between vitalism, materialism, and mechanism is crucial when examining the relationship between human bodies, minds, and souls and the role of technology in shaping them. It is also essential to recognize that the body, mind, and soul are all subject to ordering ways of thought and control, highlighting the potential for technology to manipulate and obscure human thoughts and emotions.

Foucault's (1991) concepts of governmentality, biopower, and biopolitics provide valuable insights into these issues, revealing how power operates through knowledge and discourses. Additionally, the idea of biopedagogy (Harwood, 2006) emphasizes the role of education in the regulation and control of bodies and identities, exposing the broader social and political implications of educational practices. These entities do not act in isolation, but as immutable mobiles (Latour & Woolgar, 2013) can be applied to various educational technologies as a means to discipline and control individuals and populations.

It is essential to acknowledge that theoretical and practical applications that work in one realm may not be applicable in another, and positive outcomes in one context do not guarantee similar results elsewhere. Without regularly revisiting our tools and technologies, we risk merging with the engineered world to creating incontestable entities in the form of problematic humanoids, artificial intelligences, and cybernetic systems. While our limitations in these areas do not stem from our pursuit of expanding our understanding of our own mind and soul, but rather from our confidence in our understanding of them.

The interconnection between humans and machines is not a recent development exclusive to modern times. The bond between humans and machines has a rich past that encompasses numerous cultures and legends, such as enchanted thrones and mechanical creatures, in addition to romantic tales of human-machine partnerships. It is imperative to explore the tales of automatons from various cultures and the coexistence of beliefs about machines and humans. Furthermore, the concept of a mechanical brain is not novel, and its association with computers, cybernetics, and artificial intelligence has become a commonplace concept.

5.3 Engineering Education and STEM as Limited and Mechanically Defined

Educators often rely on linear and one-dimensional approaches to teaching, which prioritize trial and error and causality. However, this approach fails to account for the complexity of the subject matter and the diverse needs of students. As interactions between humans and computers become more integrated, we risk creating incontestable entities like humanoids, artificial intelligence, and cybernetics if we fail to regularly revisit our tools and technologies. New constructions may introduce unexpected complexities that require more than simple solutions. The limitations we face in understanding the mind and soul do not stem from our pursuit of knowledge, but rather from our confidence in our understanding of them. For instance, while the human eye is often praised for its design and function, its complexity lies in the system that processes images, which has been explained through various mechanical workings over the centuries. The complexity of the eye lies not in its existence, as it is relatively easy to describe, but in the system which processes images. It is the concern which allows for the complexity to emerge. The same system that, over centuries, we have tried to explain through many planes of mechanical workings.

This is no different when the child is of concern. In the ways of making the child, of mapping the brain, of balancing biochemicals, and of testing the mind and spirit, it begs to question how much of the child has been "made-up" or imagined. Mechanical, capacity, and engineering metaphors of power limit how a child can be imagined and who could be imagined as a child. New theories and technologies of power opened up the move toward child-centeredness while also providing the tools for critiquing its foreclosures. Baker (1998b) imagining the child has become bolstered by the science, engineering, and technology assemblage through new disciplines like cognitive science in the mid-twentieth century. During the early days of brain research, pioneers such as Herbert Simon, Andreas Vesalius, and Santiago Ramón y Cajal [64] were among the first to establish connections and assert certain visibilities of the brain.

Through outcomes-based analysis, scientific models of the brain made the unseeable seeable through particular confidences in continuity outcomes and universal bodies. Similar to how many pathologies exist, patients are diagnosed or imagined through tests and technologies that assume certain consistencies. The instance of the human mind as a computer has been argued.[65] for the better part of a century. The tendency of progressive focused individuals to prioritize a disciplined and mechanized mind in the pursuit of knowledge has been shaped by various socio-political, educational, and scientific factors. This approach seeks to understand how the mind operates and how such knowledge can be applied to complex thinking systems, including those

[64] Herbert Simon (1916-2001) was an American economist and political scientist who made significant contributions to the fields of artificial intelligence, cognitive psychology, and organizational theory.
Andreas Vesalius (1514-1564) was a Flemish anatomist and physician known for his influential work "De humani corporis fabrica" (On the Fabric of the Human Body).
Santiago Ramón y Cajal (1852-1934) was a Spanish neuroscientist who is best known for his extensive research on the structure of the nervous system, particularly the discovery of the individuality of nerve cells, or neurons.

[65] Arguments for the Human Brain as Computer Theory include the analog processes of the human brain compared to the digital processes of a computer-by-computer scientist John von Neumann, the impossibilities of compatibility between linguistics and computer languages proposed by linguist and philosopher Noam Chomsky, and the definitive differences between man and machine by George Miller.

related to computers, artificial intelligence, and social media platforms.[66] This last platform being the newest and most interesting is based on a framing of groupthink extrapolated to become something of a super entity.

The epistemological phenomenon in which individuals in the Westernized world understand both the material and non-material aspects of their existence through engineering processes developed from and with science and made credible through technologies has given rise to the technoscientific life. This assemblage of science, technology, and engineering has led Westernized societies to seek concrete solutions to problems within and among themselves. Mechanized rationalities of minds, bodies, and souls have become normalized, just as a computer can be explained mechanically. Throughout history and into the present, regimes of truth have shaped the understanding of the self as a mechanically operative being. Synnott (2002) provides an example of this phenomenon through a popular 1921 U.S. publication that promoted the idea that, in child rearing, a baby could be trained to follow a strict schedule of eating, sleeping, bowel movements, and the like, akin to a little locomotive. And in the Deweyan mode of organization, the author adds that this programming would be advantageous to the mother's schedule and daily duties. While the concept of the mechanical mind is not new, it has become a

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[66] The establishment of standards in the 19th century aimed to apply scientific methods to achieve practical and consistent results in various areas of the westernized world, including factories. The shift from a military position to industrial efficiency was significant for engineers who utilized science and standards. In the 17th century, the idea of nature as a clockwork model emerged, where every motion of a body was explainable by the direct imparting of motion by another body, without noticeable intervention of God on a regular basis. This conceptualization allowed for rationality, precision, uniformity, control, efficiency, and ideals of harmony and regularity. The characteristics of engineering played a crucial role in the production of a given form, which emerged as a particular solution to a particular set of historical problems. (Higgins & Hallström, 2007; Smith, 2020; Alder, 1997).

taken-for-granted idea in how we consider the relationship between computers, cybernetics, and artificial intelligence. [67]

Too often, educators follow a one-dimensional approach to instruction, relying on trial and error and causality patterns. This assembly-line mentality treats students like products moving through a factory, utilizing standardized practices and prescriptive algorithms to achieve varying levels of knowledge. This linear approach requires students to follow prescribed procedures to arrive at predetermined solutions. While it can provide structure and consistency, it fails to consider the nuances of the subjects being taught, including both the discipline and the individual students themselves.

During the early 1900s, scholars such as Dewey and Vygotsky criticized the mechanical approach to teaching and learning and offered alternative educational theories. To counter this, constructivist or inquiry-based approaches were introduced, placing emphasis on exploration, experimentation, and conceptual understanding. Dewey believed that learning should be based on the student's experiences and interests, encouraging hands-on activities, and questioning to aid scientific understanding. Similarly, Vygotsky urged teachers to facilitate students' active roles in their own learning and deepen their understanding of concepts and principles. However, these alternative methods can also become too mechanized, limiting students' exploration of

[67] Myths of automata have been found across many cultures, including stories of magical thrones and mechanical beasts, as well as love stories between humans and machines. This latter myth persists in contemporary media, such as the film "A.I." As technology developed, there was a progression in the understanding of the relationship between humans and machines. For example, pre-Enlightenment philosopher René Descartes believed that "the bodies of animals were no more than complex machines whose internal organs could be recreated via mechanical instruments such as cams and pistons." In the Enlightenment period, interest in Newtonian physics led to the creation of more complex automata. Even before the emergence of Gribeauval's military engineering specialists, Dutch mathematician and scientist Christiaan Huygens built an entire mechanical fighting army.

sense-making and scientific methodologies, which hinders creativity and innovation. This confinement is due to Westernized scientific and engineering conventions that prioritize rationality and efficiency over diverse perspectives and modes of thinking.

Critics such as Tippins (2010) and Bybee (1993) argue that science education has been reduced to a "cookbook" or "recipe-based" approach, limiting the scope of science and constraining knowledge, methods, and actions. To combat this, educators must adopt more open-ended approaches that offer greater student autonomy and creativity by moving away from pre-designed activities and assessments. Additionally, Young-Yi (2022) argues that the constructivist approach has become too narrow and must be re-conceptualized to better reflect the dynamic nature of scientific inquiry.

As educational theory, educational psychology, behaviorism, and the advent of computer technology became increasingly intertwined, the boundaries between technology and science became blurred. With the rise of mechanized learning and the objectification of human beings, it became possible for engineering designs to become more human. In a 1978 paper, science-fiction writer, Isaac Asimov declared that as the speed in which technology moved increased in the 20th century, new ideas offered ways to think about the future (Asimov, 1978). In other words, a passive attitude towards the understanding of technology changes out perception of what is into what could be. In science education, the importance of design and an eye toward the future matched the technoscientific attitude and the minimalism of the present.

In the mid-20th century, trailblazers like Alan Turing, who first proposed the idea of a machine capable of learning from data, Frank Rosenblatt, who created the pattern-recognizing perceptron algorithm, and B.F. Skinner, a behaviorist who viewed learning as a mechanized process of stimulus-response associations, embodied technoscientific attitudes and put them into practice. As these concepts were incorporated into Piaget's developmental theories, Vygotsky's constructivism, and Dewey's hands-on materialism, the notion of transitioning from machine to child and back became increasingly popular in education, politics, and society. Once upon a time, a computer was simply a person who computed things. As these assemblages converged in the mid to late-20th century, there was a renewed desire to make humans into computers again, but this time one that was technologically advanced and capable of processing vast amounts of data.

In more recent times, entities such as algorithms, language processing, and adaptive testing have created an illusion of autonomy and objective authority. However, beneath the surface lies layers of influence, standards, and the unknown. Critical analysis is necessary to examine the foundational creations of both digital nature and the understanding of the body, minds, and souls within our complex educational systems. The singular commitment to a sociopolitical technoscientific worldview, focused on science, technology, and engineering, has resulted in a narrow focus on inclusion, innovation, and intuitive ways of seeing and being in the world. This approach is rooted in post-enlightenment thought and reemerges in education through STEM adjacent principles, solidifying a bounded and mechanistic set of knowledge and methods that parallel the ways in which Westernized technological pursuits are advancing.

5.4 The Potentials and Implications of Epistemological Pluralism in STEM Education

STEM education can benefit greatly from the idea of epistemological pluralism, which values diverse ways of knowing and understanding the world. Epistemological pluralism is the recognition and acceptance of diverse ways of understanding the world. It values the integration of different perspectives and methods in educational and research practices, promoting inclusivity. In STEM education, this approach can improve problem-solving and innovation by allowing engineers to draw on a range of knowledge from multiple disciplines. Additionally, in the field of engineering, epistemological pluralism can transform problem-solving and innovation by acknowledging and valuing multiple ways of knowing and understanding the world. This encourages engineers to approach problems with a more diverse set of problem-solving methods, resulting in more creative and effective solutions. Furthermore, this approach fosters interdisciplinary collaboration, as engineers can work with professionals from other fields to develop more holistic and sustainable solutions that consider the broader social, economic, and environmental impacts of their work. Ultimately, epistemological pluralism can help create a more inclusive, equitable, and sustainable world.

Scholars from decolonial and Indigenous perspectives, such as Smith (2012), Tuck & Yang (2012), and Tuhiwai Smith (1999), advocate for epistemological pluralism that recognizes diverse cultural, social, and historical contexts. Philosophers Lyotard (1984) and Derrida (1967) argue that there is no single, objective truth accessible through scientific or empirical means. Epistemological pluralism challenges the dominance of a single perspective and promotes a democratic approach to knowledge production. Anzaldúa (1987) emphasizes the importance of recognizing and valuing multiple perspectives in issues of identity, borders, and cultural hybridity.

Epistemological pluralism in STEM education can promote a more collaborative and diverse approach. Traditional STEM education has been taught from a narrow perspective, limiting diversity in both the curriculum and student body. Acknowledging diverse ways of knowing can create a more comprehensive understanding of complex problems and allow for interdisciplinary collaboration. Expanding the scope of STEM education to include diverse fields of study can facilitate a multidimensional understanding of scientific and technological innovations. Additionally, epistemological pluralism has significant implications for engineering as it advocates for the integration of diverse problem-solving approaches, including analytical and intuitive methods, leading to a more inclusive and effective engineering practice. It also promotes interdisciplinary collaboration among engineers and other fields, resulting in more innovative and creative solutions that account for the broader context of their work. Epistemic pluralism must be approached with reflexivity to avoid potential pitfalls, such as essentializing or romanticizing non-Westernized knowledge. Carelessly embracing epistemic pluralism could perpetuate power imbalances and result in cultural imperialism, as Westernized institutions may appropriate and commodify non-Westernized knowledge without critical examination.

5.5 The Engineer Three Ways

Engineering, as a practical application of science, has been present since humans first began shaping tools. Its purpose is to apply scientific knowledge to advance human progress by developing technologies for practical use. Engineering is closely related to scientific discoveries, observations, and methods that aid in understanding and utilizing nature. There exists a range of attitudes towards the idea of controlling nature, from domination to stewardship. Engineering is credible due to its association with scientific advancement and its impact on creating new methods for interpreting and controlling nature. Moreover, engineering has been used to study and manipulate individual bodies with the ideals of democracy and good citizenship, leading to the personalized social engineering of populations. The language of facts has become the language of ethics, limiting public moral imagination to the boundaries determined by contemporary scientific understanding.

In chapters 2, 3 and 4, the focus is on engineering and engineers as heroes, myths, and cyborg engineers. It is shown that engineering gained power through the discipline of self, the increasingly technoscientific society, and the political and economic influences that underwrote their authority. The engineer became the practical wizard of westernized thinking and progress, leading the cause of dominion and developing ways to scientize both material and non-material aspects of everyday life. Due to this new-found mysticism nestled in the STE assemblage and later in STEM itself, engineering was able to overshadow the methods and beliefs grounded in other ways of knowing, designing, creating, and building. The engineer, perceived as the mythological longing of the bricoleur, presents a vast series of dualisms, including the rational and irrational, dominant and communal, or civilized and savage.

5.6 The Hero

Gribeauval was an influential figure in the field of engineering, praised for his innovative ideas that had a significant impact on military, economic, and management practices related to design, organization, standardization, and production. He embodied the ideals of efficiency, precision, and practicality. His improvements to artillery manufacturing and design helped to modernize production by incorporating new forms of materials and technologies such as iron and steam power. Gribeauval's standardization of production methods and use of interchangeable parts enabled the mass production of artillery pieces, increasing efficiency and output. His system incorporated both hierarchies and meritocracy and was widely adopted not only in France but also in other countries, contributing to the spread of industrialization throughout Europe.

As engineering evolved over time, it became a powerful force in shaping economic and industrial associations and was closely linked to regimes of power such as science, diplomacy, religion, and economics. This created a system that established itself as a powerful entity with regards to Westernized thinking and was defined by its usefulness in particular disciplines. Engineering continued to thrive and shape the world in significant ways. But in the shaping of the world, questions arose of the limits of man and the boundaries of what would be considered natural.

The phenomena and products that could be controlled through science, engineering, and physical means became objects of interest. Science, technology, and engineering created new modes, methods, and instrumentation that allowed for the interpretation, understanding, and control of nature. The engineering of materials and methods enhanced observation, experimentation, and other scientific methods of the time. Tools, measurement devices, data, and graphs intervened in the understanding of nature and what was considered natural. These interventions allowed for the visualization of what was previously invisible. However, these interventions also became manifestations of control, expertise, and salvation through obscured corroborations of Dominion, Patriarchy, and fundamentalism (Wolf, 1994). The ability to control and manipulate through science and engineering led to a focus on phenomena and products of interest, as well as the denaturalization and treatment of perceived maladies at both personal and social levels. This emphasis on progress was apparent in the moralizing entities of the early 20th century and continues in various contexts today. The social gospel movement, for example, combined self-discipline and science to create a new religious authority that saw scientific inquiry as imbued with religious meaning and scientists as possessing pure motives. However, this commitment to using scientific methods to achieve human betterment can limit public scrutiny of particular systems and their applications. An overreliance on scientific facts can also restrict public moral imaginations and limit ethical considerations to the current scientific understanding. While those seeking progressive reforms are drawn to science because they see it as capable of creating a more perfect society, the definition of a "perfect" society is subjective and varies between individuals and groups.

Nevertheless, the ideals of democracy and good citizenship led to the personalized social engineering of populations through frameworks and systems of disciplinary practices for individuals. Science and engineering technologies, methods, and systemizations were applied in new ways to the bodies, minds, and souls of individuals. Experts emerged in various fields, rooted in the resemblances of science, and introduced new ways of thinking about medical care, psychiatric care, economic responsibilities, and ways of living. However, these so-called apolitical and empirical methods were sometimes used to justify unjust, racialized, and sexualized scientific rationalizations based on pathologies of madness (Foucault, 1990), the systemization of archaeology (Gould, 1977), and eugenics (Koza, 2021). As a result, biopolitical and biopower practices emerged as populations and bodies were disciplined, measured, counted, assessed, and sorted. These contributions from the amalgamation of science and engineering practices towards solidifying social reformations as products of social engineering.

Gribeauval's legacy in engineering paved the way for the standardization of production methods and mass production of products, contributing to the spread of industrialization throughout Europe. However, engineering's evolution led to its association with power structures such as science, diplomacy, religion, and economics, which created a system that established itself as a powerful entity with regards to Westernized thinking. While engineering continued to thrive and shape the world, questions arose about the limits of man and the boundaries of what would be considered natural. The ability to control and manipulate through science and engineering led to a focus on phenomena and products of interest, denaturalization, and treatment of perceived maladies at both personal and social levels. While science and engineering can create a more perfect society, the definition of a "perfect" society is subjective, and their overreliance can restrict public moral imaginations and limit ethical considerations. Personalized social engineering of populations through frameworks and systems of disciplinary practices for individuals emerged, but unjust, racialized, and sexualized scientific rationalizations based on pathologies of madness, archaeology, and eugenics also emerged. Biopolitical and biopower practices arose, leading to the disciplining, measuring, counting, assessing, and sorting of populations and bodies. These contributions from the amalgamation of science and engineering practices solidified social reformations as products of social engineering, highlighting the importance of ethical considerations in the application of engineering and scientific practices.

5.7 The Myth

Mythology in the context of governmentality shapes people's beliefs about power and authority through stories and symbols, which can justify and reinforce certain forms of governance. These mythological elements create a sense of collective identity and shared purpose, mobilizing support for government policies and initiatives. Thus, mythology plays a critical role in creating and maintaining a particular form of governmentality based on shared beliefs and values.

The emergence of private property, social duties, and family obligations marked a transition from an unstructured to a more socially rigorous culture, where virtues and morals shape individual behavior and expectations. This shift from physical brutality to psychological control reflects governmentality's role in shaping social norms and expectations.

The concept of the bricoleur suggests a creative and adaptable approach to problem-solving, using whatever materials and tools are available instead of relying on pre-established structures or systems. This approach challenges traditional forms of governmentality, including the mythological stories and symbols that support them, offering alternative ways of understanding power and authority. The tension between those who act and live in the style of the bricoleur, and governmentality highlights the complex relationship between creativity, adaptability, and social control in shaping how we perceive and interact with the world.
Levi-Strauss's depiction of the bricoleur as a primitive figure reflects the prevalent cultural biases of his era, where non-Westernized cultures were often viewed as backward or uncivilized by Westernized intellectuals. As Levi-Strauss grappled with his hierarchical framing of the bricoleur in relation to the engineer, his views on bricolage evolved over time. Nonetheless, his work is

part of a broader trend of European and American scholarship that aimed to classify and comprehend non-Westernized cultures according to European standards of rationality and progress.

My own research concentrates on the social and political implications of rationality, specifically in how it relates to problem-solving in modernity and its development as a pedagogical concept in educational settings. The shift towards a more rational system of belief was driven by a growing enlightenment and progressive view of existence in Westernized societies, which aimed to promote a shared rationality, epistemology, and ontology and reconcile warring sects. In this sense, enlightenment rationality became a form of salvation, replacing spiritual ways of comprehending the world.

Scientific thought is also heavily reliant on rationality, influencing the creation of disciplines and institutions that construct systems around rational scientific thought to provide explanatory power, predictability, and objectivity. Rationality serves as a universalistic force of judgment on validity over all local and temporal boundaries, doubting what cannot be verified by a trusted scientist or expert in the field. Scientists and technoscientific advancements have created a model of thinking grounded in rational scientific theory and methods, designed into specialized methods based on the cyclical advancement of science, technology, and engineering. They are modern magicians and demystifiers who use science to reveal the secrets of nature, aiming to bring the invisible into the visible world.

Levi-Strauss's argument portrayed primitive cultures as lacking the ability to think abstractly and systematically, suggesting that bricoleurs in these cultures rely on trial-and-error and are unable to plan or anticipate outcomes. He contrasts the bricoleur with the mythical and heroic engineer, who is associated with Westernized scientific tradition and progress through technological innovation. Although these archetypes appear to be in opposition, they are not mutually exclusive. The mythical engineer is often viewed as an ideal to strive towards, while the bricoleur serves as a reminder of the importance of diverse perspectives and approaches to problem-solving. The bricoleur's improvisational and creative nature highlights the value of creativity and resourcefulness, which can be just as significant as scientific knowledge and rational thinking. Therefore, the bricoleur can be seen as a valuable counterbalance to the myth of the engineer and a reminder of the importance of embracing diverse perspectives and approaches to problem-solving. Additionally, Modern-day bricoleurs are known for their ability to solve problems creatively using unconventional methods and materials, unlike traditional engineers. They often rely on intuition, experimentation, and improvisation to develop innovative and unexpected solutions. Three examples of modern-day bricoleurs are hackers, DIY enthusiasts, and artists and designers. Hackers use unconventional methods and trial-and-error to solve complex computer science problems. DIY enthusiasts rely on their own creativity and intuition to design and build functional and aesthetically pleasing objects. Many artists and designers use unconventional materials and techniques to create unique works of art and design.

The bricoleur, a human construct, operates similarly to an engineer but with a more culturally focused approach to production methods and ways of thinking. This raises questions about how engineering methods have been utilized to create epistemologies for things beyond our normal senses, despite a commitment to the material world. It is worth considering how extensions of sensation, resulting from the enhancement of senses, have been adopted as scientific assertions over time. Society's desire for comfort and progress has led to a reliance on technoscientific systems that are difficult to separate from alternative ideas. Engineering design principles are becoming increasingly pervasive in fields such as psychology and sociology, leading to suggestions of Westernized superiority based on applications or scientizations of certain intangibles. Psychologists use technoscientific and engineering designs to make the invisible visible through tools such as IQ tests, which measure intelligence based on limited forms of knowledge. Tools for motivation and thought organization are used to categorize individuals into specific disciplines. Similar tools, such as those measuring interest, persistence, and grit, are gaining popularity, and the normalization of the unseeable into disciplinary technologies moves power from the body to the mind and soul.

The human body has been viewed as a regulated entity, similar to a machine, with its own functions, abilities, limitations, and utilities. According to Foucault, disciplinary power exercises control over the body, optimizing its capabilities, extracting its energies, increasing its usefulness and obedience, and integrating it into systems of efficient and economic management. Power is exercised through science and society, driven by the pursuit of greater comfort and well-being. During the 18th and 19th centuries, industrialization became the dominant technoscientific norm in Westernized societies, promising a higher standard of living and a greater degree of submissiveness.

Society became an experimental laboratory that produced new objects for thinking about experience as comparative data for planning and programming the utopic images of the good life. The formation of a social science apparatus entailed new institutional structures and actors. Many Westernized universities became sites to administer large governmental grants for research to organize large data sets about targeted populations and to provide the technical expertise for the methodological development of mass observational techniques. All this in the name of a secure and better life.

In his analysis, Foucault (1977) explains that "security" strategies aim to manage societal forces and movements by intervening directly in the environment occupied by society's members. Instead of simply dividing things into permissible and prohibited categories, an optimal average is established with an acceptable range that must not be exceeded, exemplifying biopower. These newer methods involve identifying the problem, collecting massive amounts of new data, peer-reviewing approaches, and applying systems, dialogs, and standards related to reliability and validity. This act of governmentality, helped to create people and groups. In this way, Foucault's (1991) concept of governmentality can be linked to social engineering and psychology, which have been used to manipulate individuals and groups in various forms of governmentality, ranging from the management of the population to the regulation of individual behavior. Engineering design and implementation are intertwined with governmentality and social engineering, raising questions about the ethical implications of engineering and its impact on society. The incorporation of different disciplines has created and legitimized new ways of making knowledge, shifting identities from historical, cultural, and literature contexts to more scientific-centered self-awareness.

Chapter 3 thoroughly explores the theme of mythology and governmentality, emphasizing the importance of diverse problem-solving approaches. Through the concept of the bricoleur, it challenges the idealized engineer in Westernized society. The emergence of governmentality and biopower as forms of disciplinary power that categorize and control people based on beliefs, epistemologies, and ontologies is also examined, highlighting potential power struggles over knowledge and means of production. The chapter also explores the connections between engineering design principles and forms of control that become commonplace in societies seeking progress and comfort. It also analyzes the normalization of categorizations and the use of disciplinary technologies that move power from the body to the mind and soul. The critical analysis of Foucault's statement on disciplinary power demonstrates how it controls and measures the body through disciplining, optimization, extortion, and integration into efficient and economic systems of control.

Mythology and rationality have both played significant roles in shaping people's beliefs about power and authority. While mythology uses stories and symbols to create a shared, rationality has replaced spiritual ways of comprehending the world with a form of salvation based on scientific thought. Scientific thought heavily relies on rationality, providing explanatory power, predictability, and objectivity, serving as a universalistic force of judgment on validity over all local and temporal boundaries. However, this also raises questions about the adoption of engineering methods to create epistemologies beyond our normal senses, leading to a reliance on technoscientific systems that are difficult to separate from alternative ideas. The bricoleur, operating similarly to an engineer, highlights the value of creativity and resourcefulness in problem-solving and offers alternative ways of understanding power and authority. However, the normalization of the unseeable into disciplinary technologies moves power from the body to the mind and soul.

In light of this, it is crucial to recognize the limitations of Westernized standards of rationality and progress and embrace diverse perspectives and approaches to problem-solving. The bricoleur serves as a valuable reminder of the importance of creativity and resourcefulness. This view challenges traditional forms of governmentality. As the world becomes more complex, the need for innovative and unconventional approaches to problem-solving becomes more apparent. Therefore, it is essential to foster an environment that values diverse perspectives and promotes creative thinking, as well as to question the adoption of technoscientific systems that may limit alternative ideas. By embracing diverse perspectives and promoting creative thinking, we can create the potential for a more innovative and inclusive society that values different ways of understanding power and authority.

5.8 The Engineered

Educational systems are not neutral spaces for the transmission of knowledge, but rather shaped by historical, social, and cultural factors that determine what knowledge is valuable and who has access to it. In the context of alchemy, ways of knowing taught in schools are not objective but influenced by social biases and cultural norms. The focus on outcomes-based information in psychology and sociology is not neutral but shaped by underlying assumptions and values about what constitutes desirable outcomes and evidence. Popkewitz's (2012) perspective encourages critical examination of these underlying assumptions and values to consider alternative ways of understanding and practicing education that account for complex and diverse social and cultural contexts. The narrow emphasis on design, methods, and knowledge in the education of engineers not only shapes their identity but also reinforces the mechanical mind and its connections to Cartesian thinking. This approach to science put the will of defining and naming all "essences" of the human experience.

Empiricists expanded upon this approach, arguing that unseen things could be created in scientific, technological, or engineering forms by means of methods, standards, and quantifications. As a result, scientists developed modes of modeling and pathologies to explain the unseeable in new technological ways. This reasoning about the engineer and the creation of the engineer enables seeing the complexities of the human experience as rationalized commonsense models used to define, measure, and assess certain normalities and abnormalities.

The integration of science, society, and power has had a significant impact on the field of engineering, which has traditionally focused on the mechanization of the body but is now expanding to include the mind and soul. Westernized progressives have utilized this concept to achieve various goals, such as economic opportunities, technology, and exceptionalism, and STEM education has become increasingly popular as a means of achieving success for children. However, the categorization of individuals as science or STEM (dis)abled or worthy of status based on metrics and attitudes perpetuates power imbalances and reinforces particular societal and educational norms. Efforts towards inclusion often fail to address the systemic issues that create the marginalized individual, hindering progress towards equity.

Engineering is a constantly evolving function that requires expertise and systematization to solve problems. The transformation of engineering has opened up new possibilities for subjectification and application across all entities, including the human soul. The normalization, measurement, and sorting of individuals have become essential in Westernized cultures as a means of disciplining behavior and promoting competency. The formation of technologies and assessments of normalization turn towards science and systemizations to establish legitimacy, creating an aura of progressiveness through scientization and rational doctrine.

Rose introduced the term "Engineering the Human Soul" to describe the role of new "engineers" in liberal democratic societies who shape the soul to reflect scientific techniques and the moral claims of humanism. The soul is engineered through a regime of power that works on it to inscribe a particular "knowledge" that becomes an automated pattern or identity. The positioning of the body in space and time affects the "psychology-effects" of the soul, leading to disciplinary outcomes. Quantifying humans, or measuring and evaluating people based on numerical data, acts as a form of discipline that creates a system of surveillance and control over individuals. Disciplinary power makes individuals visible and measures them to regulate their behavior. This disciplinary power is a manifestation of the broader system that characterizes modern societies and is reliant on measurable entities that validate mathematics and quantifications as superior forms of evidence and analysis.

According to Rose (1992), calculability is a central theme in much sociological and philosophical reflection on the uniqueness of the West and the particular characteristics of the social arrangements and ethical systems that have emerged in capitalist, bureaucratic, and democratic societies. As a result, centers of calculation (Haraway, 1991) have shifted their attention from the realm of natural philosophies to the quantification of humans themselves. The emergence of the calculable person allows individuals to be quantified, evaluated, predicted, and managed. This system of engineering occurs in spaces where bodies and behaviors require discipline and management, such as schools, factories, prisons, railways, and mines. The system resembles the scientization and calculability in psychology and is not limited to this field alone.

In 1893, Durkheim (2014) used the term "organ of moral discipline" to describe the process of rationalization and reasoned management, which was used to engineer morality in both colonized people and those sent to colonize. This was accomplished through state-approved experts, referred to as "cultivated men," and involved the use of calculus as a technique of measurement and management to create areas of normality and acceptability across various entities. An example of this technique was the use of measuring and assessing particular behaviors of "the mad," which resulted in particular punishments and degradations that were administered in a passive and neutral way. This had two significant effects on the body: firstly, it made it clear that certain behaviors were not normal by means of some measure, and secondly, it internalized the punishment as a way of blaming oneself for deviating from the norm. This technique was not limited to asylums, but also found its way into prisons, schools, hospitals, and other institutions and remains prevalent today.

STEM education and engineering rely heavily on quantification and data-driven decision-making, which can have both positive and negative effects. While a focus on empirical evidence and quantitative analysis can lead to innovative solutions, an overemphasis on standardized assessments and quantification may neglect important aspects of STEM education, such as creativity, critical thinking, and ethics. Therefore, a balanced approach that values both technical and social skills is essential for addressing complex challenges. The evolution of governmentality and state control has important implications for STEM education. The level of control has become more personal and exponential, with a growing need for scientists and engineers who have a deep understanding of biology, chemistry, and related fields to work on projects related to biotechnology, genetic engineering, and other areas where molecular control is possible. Furthermore, the increasing prevalence of data-driven technologies in STEM fields requires a focus on data analysis and computational thinking in addition to traditional scientific and engineering concepts. However, the use of quantification in education policy has become problematic in some ways, including neglecting important aspects of education and unintended consequences such as a limited curriculum and teaching to the test. As STEM education becomes increasingly important in shaping the future of science and technology, it is crucial that educators address ethical concerns and prepare students to make informed decisions about the role of science and technology in society.

5.9 The Modern Intersection of Technology and Intelligence

On November 3rd, 2022, the CEO of Twitter shared a tweet, describing the platform as a "collective, cybernetic super-intelligence" due to the billions of bidirectional interactions taking place on the site. This statement resonates with my interest in exploring the creation and measurement of intelligence and the potential limitations of rationalizing intelligence through science and technology. However, I argue it is important to acknowledge that science and engineering are interdependent fields that rely on each other for progress, but their fallibility in problem-solving and objectivity must be recognized. The computer age has led to an exponential increase in problem-solving systems, with a reliance on desired outcomes, data processing, binary conditionalities, classification, and cybernetic thinking. While this approach has been used in studying evolution, it is fallible with regards to problem-solving and objectivity. Artificial intelligence has replaced human beings in various fields, performing numerous procedural and repetitive tasks, but societal common senses based on computer programs and algorithms complexify social common senses and obscure new ways of creating, disciplining, and categorizing people.

The idea that discipline no longer acts primarily on the body or mind, but on a more complex version of the being, the soul, is an important one to consider. With the expansion of technology and the growth of surveillance, lives are increasingly monitored and categorized. This network of surveillance and scorekeeping, based on a professed objectivity, has been created through an expansion of rationality that has been driven by multiple historical episodes of scientization.

As we continue to rely more heavily on technology, it is essential that we maintain awareness of the potential negative consequences of such reliance, including the loss of privacy, the erosion of individual agency, and the perpetuation of systemic biases. To mitigate these risks, it is important to consider the ethical implications of technological advancements and to take steps to ensure that technology is developed and deployed in a responsible manner. Ultimately, the idea that discipline no longer acts primarily on the body or mind, but on the soul, underscores the importance of maintaining a balance between technological advancements and human expertise.

5.10 Exploring the Impact of Cybernetics and AI on Education

The application of cybernetics to education has significantly impacted the learning process. Stafford Beer and Gregory Bateson were key contributors during the 1960s. Beer's concept of the "cybernetic classroom" viewed education as a self-organizing system that provides personalized instruction adapting to individual student needs. Bateson's theory of learning proposed that learners adjust their behavior based on feedback from the environment. While cybernetics has brought about many positive advances in education, there are also criticisms and limitations to consider. One critique of cybernetics is its focus on individualized learning experiences and the potential loss of a sense of community and shared experience in the classroom (Hamel, 2014). In addition, some scholars argue that cybernetics places too much emphasis on technological solutions to educational problems, neglecting the importance of human relationships and social contexts (Feenberg, 2009).

Moreover, there are concerns about the standardization and normalization of learning experiences that can arise from the use of cybernetic principles. As Popkewitz (2004) notes, cybernetics can lead to the creation of standardized systems that differentiate and distinguish individuals based on their performance, leading to potential issues of exclusion and discrimination. This can result in a narrow focus on predetermined learning outcomes and standardized assessments that do not necessarily reflect the diverse needs and experiences of learners. In light of these criticisms, it is important to consider the potential drawbacks of cybernetics in education, and to ensure that it is used in a way that balances the benefits of personalized instruction and technological innovation with a recognition of the importance of human relationships and social contexts.

While the potential benefits of cybernetics in education are numerous, there are also valid concerns about its drawbacks. Furthermore, the standardization and normalization of learning experiences that can arise from the use of cybernetic principles can lead to issues of exclusion and discrimination. As such, it is important to consider the potential negative consequences of cybernetics in education and to use it in a way that balances its benefits with a recognition of the importance of human relationships and social contexts. Haraway's (2006) "cyborg" perspective offers a unique lens through which to view the relationship between humans and technology, and its emphasis on the hybrid nature of our existence is particularly relevant in the context of cybernetics and education.

Haraway's (2006) perspective on technology and society challenges the traditional separation between humans and machines and emphasizes the hybrid nature of our existence. Haraway argues that the figure of the cyborg represents a new possibility for understanding the relationship between humans and technology and can be a source of resistance and empowerment. In her view, the cyborg is a creature in a post-gender world, and it challenges the notion of human exceptionalism and the idea of a natural, essential human identity. Instead, she proposes creating new forms of social and political organization that reflect the hybridity of our existence. This perspective has implications for engineering and technology. It emphasizes the need to be mindful of the ways in which these fields are influenced by social and cultural factors and to work towards creating technologies that reflect a more diverse and inclusive understanding of human experience.

N. Katherine Hayles' book (1999) “How We Became Posthuman" examines the impact of cybernetics and information technology on human identity and subjectivity. Hayles (1999) argues that this has blurred the boundaries between human and machine and created a new paradigm of the "posthuman." In this paradigm, human identity is seen as a complex and dynamic system of interactions between humans and machines. Hayles (1999) explores how cybernetics has influenced various fields, including literature, art, and philosophy, and has played a crucial role in shaping postmodern culture. She contends that the posthuman paradigm presents ethical and political challenges by challenging traditional ideas of autonomy and responsibility and demanding a more nuanced understanding of these concepts.

These perspectives on cybernetics and the posthuman paradigm offer valuable insights on how to respond to the impact of technology on education. They underscore the need to recognize and embrace the hybrid nature of human experience, and to create educational systems that are more inclusive and participatory. By thinking critically about the ways in which technology is shaping our world and ourselves, we can ensure that education is designed to promote a more nuanced and optimistic view of the future. By using cybernetics in education in a way that balances the benefits of personalized instruction and technological innovation with a recognition of the importance of human relationships and social contexts, we can avoid potential drawbacks such as standardization and normalization of learning experiences.

Several concerns have been raised regarding the potential impact of artificial intelligence (AI) on children's education. One such concern is that AI may lead to the dehumanization of the learning experience, with technology replacing human interaction and personalization, thus negatively affecting the development of social and emotional skills critical for success in life. Additionally, there is a worry that AI may reinforce existing biases and inequalities in education by perpetuating discriminatory practices based on biased data. Finally, the impact of AI on the job market and the skills necessary for success in the future is also a concern.

Popkewitz's (2019) work on AI and education provides important insights into the implications of this technology for the human subject, power and control, and social justice. He argues that a more nuanced understanding of the complex interplay between consciousness, intentionality, and social context is necessary to ensure that AI use in education is not dehumanizing. Critical reflection and engagement with AI in educational settings is also necessary to avoid reinforcing existing power structures and inequalities.

Digital technology and AI are transforming our understanding of knowledge and expertise, according to scholars such as Hayles (1999), Deleuze & Guattari (1987), and Bauman (2000). These scholars suggest that we need new conceptual frameworks for understanding this transformation and emphasize the importance of a critical and reflexive approach to technology. Scholars like Watters (2016), Williamson (2017), and Bayne (2015) focus on the intersection of technology and education, particularly the ways in which new technologies, including AI, are changing the nature of teaching and learning. They are interested in the ethical and political implications of these changes and how they are impacting the relationships between teachers and students.

The application of cybernetics in education has brought about significant advances in personalized instruction and adaptive learning. However, the potential drawbacks, such as the standardization and normalization of learning experiences and the loss of a sense of community in the classroom, need to be considered. Donna Haraway's "cyborg" perspective and N. Katherine Hayles' book "How We Became Posthuman" offer insights on how to respond to the impact of technology on education, emphasizing the need to recognize and embrace the hybrid nature of human experience. The use of artificial intelligence (AI) in education is also a concern, and critical reflection and engagement with this technology is necessary to avoid reinforcing existing power structures and inequalities. Ultimately, the benefits and drawbacks of cybernetics and AI in education must be balanced to ensure that they are used in a way that promotes inclusivity, diversity, and social justice.

5.11 Reimagining STEM Education: The Multidimensional Aspects of Knowledge and Power

This dissertation on knowledge and its power in STEM and the STE assemblage calls upon all educators to consider the multidimensional aspects of the world in their teaching practices, recognizing the interconnectedness of history, philosophy, anthropology, and materiality. The dissertation stresses the relevance of these dimensions in STEM education, where the scientific rationality often oversimplifies complex phenomena. Thus, it is essential for educators to adopt a more diverse and inclusive approach that reflects the complexity of the world. By questioning their assumptions, educators can promote a more inclusive and holistic approach to education, which emphasizes the importance of diversity and inclusivity in STEM subjects. This inquiry has the potential to a fresh perspective on teaching STEM subjects, which can help students develop a more nuanced understanding of science, engineering, and technology.

STEM educators can utilize the analytical tools of power to better understand the ways power operates within their classrooms and schools. By examining the distribution and exercise of power, educators can identify areas where biases and inequalities exist. This can lead to a more inclusive and diverse approach to science education, where students from all backgrounds feel valued and respected. In addition, STEM educators must recognize the broader societal issues that contribute to biases and inequalities, such as gender and racial stereotypes in popular media and cultural narratives. By acknowledging and addressing these issues, educators can work towards creating a more equitable and just society for all. It is vital to challenge the assumptions about who can succeed in STEM fields and provide support and encouragement for students from underrepresented groups.

5.12 Conclusion

The prevalence of Westernized ways of life has led to a dominance of engineering and technology in our society, shaping our beliefs, values, and behaviors. While engineering has undoubtedly brought about significant advancements and improvements, it is essential to recognize the impact it has on marginalized communities and to critically examine its narrow view. By doing so, we can create a more inclusive and reflective approach to engineering that recognizes the diversity of human experience. The power of knowledge accessible to teachers cannot be underestimated. By exposing the influence of engineering on our thinking and planning, we can challenge dominant narratives and ideas, creating a more objective understanding of its role in shaping society. Additionally, encouraging educators to take a critical approach to teaching engineering will result in a more inclusive and reflexive approach that better serves all members of society.

Finally, it is crucial to recognize the broader issues surrounding engineering's impact on society, particularly the growing concern about the impact of artificial constructs on the human mind. As technology continues to advance, we must be vigilant about the potential negative effects and work to mitigate them. I hope to have shed light on these issues while providing a roadmap for a more thoughtful and inclusive approach to engineering. By doing so, we can harness the potential of engineering and work to ensure that it benefits all members of society, not just the privileged few. Here, it is worthwhile to revisit the work of Jonathan Swift (1726) and his literary masterpiece, *Gulliver's Travels.*

Gulliver's visit to Laputa in "Gulliver's Travels" serves as a powerful critique not only of European intellectuals but also of the arrogance of science and technology. Laputa is a floating island inhabited by scientists, mathematicians, and inventors who are very intelligent but often have impractical or absurd ideas and little understanding of themselves and each other. Swift's satire highlights the dangers of intellectualism divorced from empathy, social awareness, and practical considerations. It is a reminder that knowledge and education should be grounded in a sense of fairness and that the pursuit of progress should always be checked against the well-being of all individuals and society as a whole.

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Appendix 1

From (Kantor, 1963, p. 361):

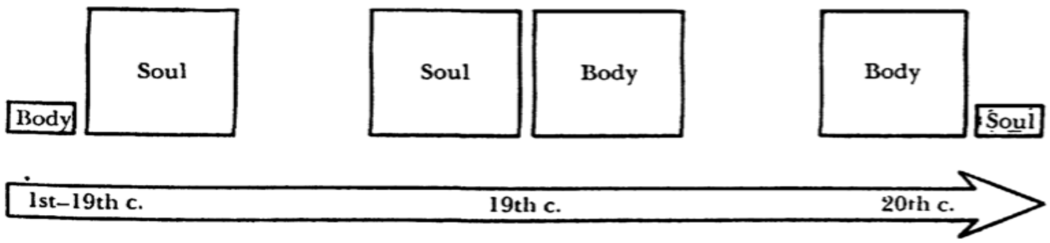

FIG. 23. THE VARYING IMPORTANCE OF BODY AND SOUL IN PSYCHOBIOLOGY

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