Thesis Project Portfolio

Design of a Pembrolizumab Manufacturing Plant Using Continuous Bioprocess Technology and Single-Use Bioreactors

(Technical Report)

Taking Shots at Shots: How Misinformation on Twitter & Facebook Shapes Risk Perception and Could Lead to the Collapse of the Vaccine Network

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Table of Contents

Sociotechnical Synthesis
(Executive Summary)

Pharmaceutical Risk: Producers Minimize it, We Misinterpret It

My STS research project and my technical capstone project captured two different perspectives on pharmaceuticals: the public perception of vaccines and the manufacturing of the protein therapeutics. The technical project is a design of a manufacturing facility for Keytruda, a cancer drug owned my Merck. The STS research went beyond the manufacturing of the drug to an analysis of how social media are driving high levels of perceived risk in the public's mental model of vaccines and threating the vaccine network. Researching these two topics together illustrated the disconnect between the pharmaceutical companies and the public that alone is not obvious. The key insights came from the compassion of the regulatory hoops I jumped through designing various safety features and protocol juxtaposed with rising trend in vaccine risk perception via noncredible sources such as Facebook. The specific effects was understanding the threats to public acceptance of vaccines had on design features of the manufacturing facility, include choice of input material usage and quality control budgeting which effect the optics or perceived quality of the product. Conversely, the technical project shaped the way I thought about vaccines and pharmaceutics in general because it illustrated how stringent the safety requirements are for vaccines. These include intense quality control and several redundant steps in the purification stage of manufacturing, which ensure proper removal of everything from DNA to endotoxins. This detailed understanding of the ways pharmaceutical manufacturers minimize the risk associated with vaccines caused me to gain trust in the vaccine producers. This opened my eyes that most non-technical persons who do not gain this understanding do not have a level of verification in which to base their trust, illustrating to me why they might have risk perception more susceptible to misinformation.

The technical portion of my thesis produced a design for biomanufacturing facility to manufacture Merck's Keytruda. The process was novel in that it was a completely continuous process and utilized single use materials. These two unique features of the process help improve efficiency of material usage as well as lower environmental impact. Unlike almost all current biomanufacturing plants, constantly producing product rather than producing in large batches. Significantly improves yield efficiency, input material requirements, and physical space required. We designed a perfusion style bioreactor and networks of chromatography columns to make this process possible. The bioreactor, rather than growing a batch of genetically modified cells in prepacked media, is constantly fed and has an outlet stream harvesting the secreted protein which increases production rate. All of the bioreactor materials being single use greatly diminishes cleaning material reequipments improving costs and environmental footprint. Chromatography networks have a precise schedule with residence time designed to always keep one column accepting product and one column producing product to maintain continuity. The only significant drawbacks are related to the fact that the process is innovative and thus poses the risk to unforeseen challenges. The STS research portion of the project caused an increased attention to be paid to quality control such that these unforeseen challenges do not diminish safety standards.

The STS research I conducted investigates risk perception from the perspective of the social media using public. This illustrated how antivaxxer social medias influence on public risk perception of vaccines can erode the vaccine network. I used foundational reading of Slovic's "Beyond Numbers: A Broder Perspective of Risk Perception and Risk Communication" to understand how exactly groups can use misinformation effectively on social media to influence public risk perception. I found that by capitalizing on current distrust of the pharisaical

companies with technically confusing language or emotional messaging, the paradigm of expressed preference favored antivaxxers sentiment. With this in mind, I realized that my understanding of the both quality control and the research and development process is not common among the public and thus the viral nature of social media gives misinformation an amplifying effect which erodes the vaccine network relationships between the public and relevant actors, especially manufactures. I found this significant because vaccines require high community enrollment yet the mental models the public hold are more individualistic. My research into how this has affected analogous GMO and climate change efforts postulates that vaccine networks also could suffer if either mental model of vaccines do not align with the vaccine capabilities or social media regulation doesn't improve.

The STS research portion has a significant effect on the technical design part of the project because it opened my understanding of how skeptical of the pharmaceutical industry's product the public is. By learning about how the manipulation of misinformation on social media can cause scientifically sound topics to become the subject of public dissatisfaction, I realized how important optics are. This enriched my technical design by causing us to go above and beyond the quality control testing requirements. More frequent testing along with a well-thought-out plan of action for test failures were the direct result of considering how this novel process would appear to the public. Without thinking of the vaccine network, the conservations of the relationship between the manufacturing and public actors would likely not have been considered and this aspect of the design done to a minimum government requirements level. By participating in these projects, I expanded the network I originally expected to utilize to write the STS research portion. Originally, as seen in blue portions of figure 2, I had expectations of a small network that consisted of professor feedback and intense internet research. In totality, I

ended up using a larger network with the orange actors in figure 2 playing an important role. My advice to rising fourth years here would be to think hard early about the actors you will need in the network of composing your STS research.

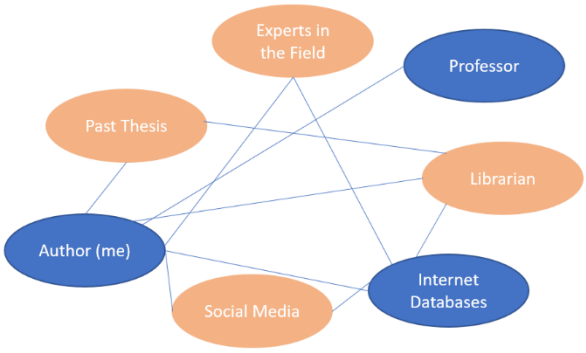

Figure 1- Network of STS research paper composure. Blue denotes my expectation; orange denotes what I actually needed to successfully complete the project.

When I began to tackle this project, I did not understand where the most critical parts of the project were. I thought it was all about the research so I rushed into picking a topic. For future fourth years, I would advise the flow chart in figure 2 as a guide for your expectations about how in-depth certain phases of the project should be. The looping structures, are the most important structures I initially overlooked. It cost me time and effort as I changed my project topic several times.

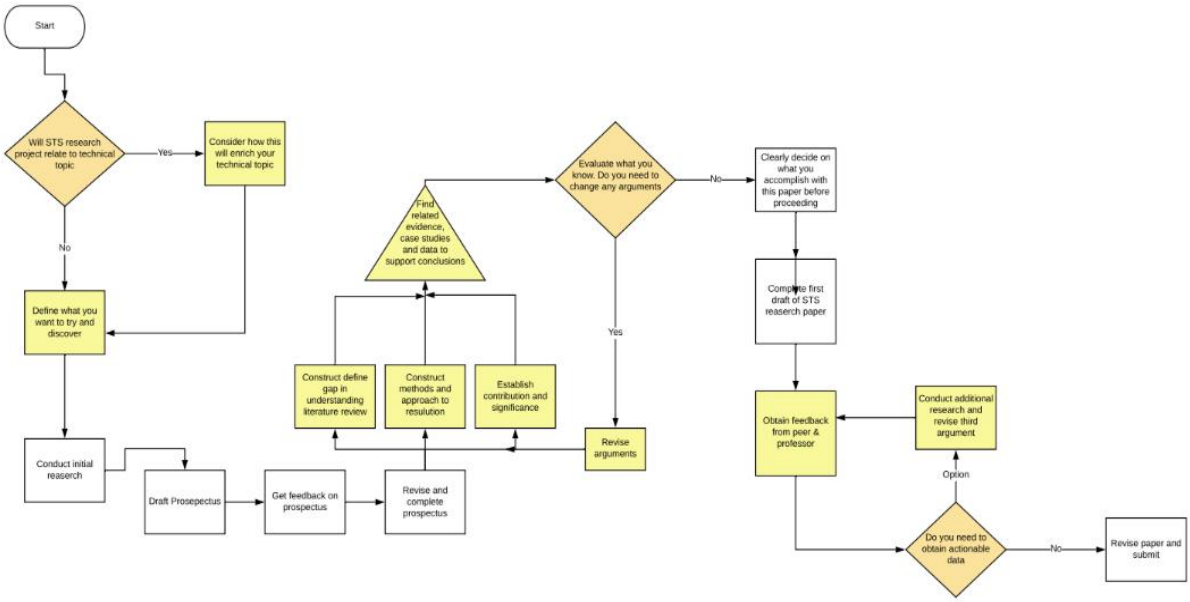

Figure 2 - Flow chart for STS composition. Yellow highlights important looping structures with orange decisions