

To: Kirmser Undergraduate Research Award
From: Andrew W. Woolley
Topic: Reflective Essay Regarding Research Practices

I am asking you to consider my project report that I completed this year for the American Institute of Chemical Engineers (“AIChE”) Student Design Competition. Each year, seniors in the Kansas State University Chemical Engineering (“ChemE”) program are required to research and prepare a report for this competition, with the goal of designing a solution to an actual engineering design problem.

The AIChE project coordinators select a project topic and problem each year, generally in the field of bioprocessing. The project is disclosed to ChemE students in the spring semester. We are given 36 days to research and prepare a report that fulfills the requirements of the problem. Students can compete individually or as a team. I competed individually.

This year’s problem topic was vaccine production with three primary focus areas: Cellular cultures used for producing viruses, the technology for producing the vaccines, and the economics of using that technology.

The first thing I did was read all of the documents provided by AIChE. This year, AIChE provided twenty recommended research sources, of which I eventually used thirteen. The recommended sources included published articles, research books, textbooks, presentations from subject experts, and websites from various groups, such as the CDC, vaccine manufacturers, and design firms. I used the recommended sources to establish the initial direction of the design, but the sources lacked enough information to complete the problem.

The recommended sources were very useful for the “upstream” portion of the project, but lacked information regarding the “downstream” process. The initial research helped me to decide the type of technology I wanted to utilize. After about one week of reading the recommended sources, I was able to choose the type of process and cellular cultures that I would recommend.

The next step was to choose and design the downstream process for manufacturing the vaccine. I used a search engine and K-State’s databases to find different manufacturing processes. This search was not easy because the technology used for cell-based vaccine production is relatively new. I focused on finding general process flow diagrams that were attributed to specific manufacturers. Usually, the diagrams were buried in presentations written by experts and corporate representatives. However, I discovered that many of the current manufacturers had very similar downstream processes, despite differences in their upstream processes. With this information, I was able to create an actual engineering process design by using SuperPro Designer, a process design program.

For this step, I had to learn to use the SuperPro Designer program by watching training videos and reading PDF tutorials provided by Intelligen, Superpro’s parent company. While SuperPro does most of the technical design work, I had to continually research and determine the key values for each unit in the process. These key values include areas such as concentrations, production yields, reaction times, etc. My preliminary research in the AIChE sources contained

most of the information needed to design the upstream portion of the process. I needed to do significantly more research to find, analyze, and choose my key values for the downstream process, though.

When using a search engine, I would use the “Get-It at K-State” function to find new sources for my downstream process research. This method gave me access to K-State’s various subscriptions to databases, so that I could research and use well-cited and referenced reviews. As part of my determination of these sources’ reliability, I also considered a sources’ bibliography. For instance, I found *Review: Downstream Processing* to be very helpful and provided the most reliable information. The review had a large and well cited bibliography and was very helpful when analyzing the accuracy of the article. Using this information, I chose my key values and entered them into SuperPro. My next step was to perform the economic calculations for my design.

AIChE provided some sources about the economics of vaccine manufacturing. In addition, I used some of the detailed economic equations found in our class textbook, *Plant Design and Economics*. However, these sources lacked data on specific equipment. As a result, I made phone calls to equipment suppliers such as Pall and GE, who provided me with specific equipment prices. With this data, I could finalize my design recommendation.

My final step was to compile my notes and my research into a report. I kept my notes and sources recorded in a notebook. Every time I found a useful article, I recorded the date I accessed the source and any useful information, and then I saved it as a PDF or a link, if it was electronic. Over the course of the project, I examined over 80 sources. When I went back and looked through all of my sources, I discovered a problem: My sources were organized chronologically instead of by topic. I found it difficult to search between pages and ensure that each source was assigned one citation.

In addition, the unused sources created clutter in my notebook. To solve these problems, when I used a source, I noted the general topic and number of the source in red ink. This method reduced my search time between the sources.

In conclusion, the AIChE problem gave me several good lessons in practical problem solving: First, it gave me a better understanding of applied research and the need to evaluate the legitimacy and accuracy of my sources. I considered who created the source, the basis of the information, and who referenced that source. If something was well referenced and had multiple citations, I considered it legitimate.

Second, I learned a better method of understanding the topic. I divided the process into two sections and researched each section individually. As I did my research, I updated my design in SuperPro. From there, I analyzed the economics of the problem, including directly contacting the manufacturers for equipment data. Finally, I wrote the report and used my notebook and red pens to indicate how the sources were used in the report.