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Generating an Alternative Thesis Pathway: Critical Reflection of Coursework and Internships

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GENERATING AN ALTERNATIVE THESIS PATHWAY: CRITICAL REFLECTION OF COURSEWORK AND INTERNSHIPS

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Biological Engineering Program

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Undergraduate Honors Thesis

Project Summary

Since internship experiences are recognized as high impact educational practices and the honors thesis is designed to be a gateway to work beyond the typical undergraduate degree, I helped develop a pathway for BENG honors students to use critical reflection to develop an honors thesis related to internship and class experience. Then, I wrote about my own experiences to serve as an example for future BENG students who want to pursue this pathway.

My objective for this example thesis was to describe the value of my engineering and technical internships and coursework and how they have shaped my future career in Biological Engineering. I developed criteria for reflecting on my internship experiences in the form of discussion questions and then completed the evaluation process and drew conclusions about my key takeaways, which were (1) it is necessary to check work through a formal QAQC process, (2) there any many types of careers and paths to make an environmental impact, and (3) engineering economics are highly important to any project or company.

Introduction

When I began studying at the University of Arkansas, I knew that I wanted to pursue engineering due to my aptitude for math and science, my love of technology, and my desire to solve problems. I was not sure, however, which types of problems I wanted to solve or which field of engineering I wanted to study. As a part of the First-Year Engineering Program, or FEP, I took a research class that allowed me to choose a project and mentor to study with throughout my freshman year. I chose to explore the relationship between nutrient runoff, harmful algae blooms, and methods for improving water quality with Dr. Brian Haggard.

Harmful algal blooms occur when excess nutrients such as nitrogen and phosphorous from sources like fertilizers and effluent discharge flow to streams, rivers, and lakes. The algae take up the nutrients causing blooms. Then, the bloom dies off when the ambient nutrient supply runs out. Some algal blooms can produce dangerous toxins (Anderson et al., 2021; CDC, 2022), but even nontoxic algae blooms pose a threat by consuming oxygen as they decay. This can create a hypoxic environment, leaving the aquatic ecosystem uninhabitable for other organisms (NOAA, 2016). My research focused on finding the minimum lethal dose of hydrogen peroxide (H_2O_2) to kill off algae during bloom events with the intention of preserving ecosystem quality. Hydrogen peroxide is a non-discriminant oxidizer and has been used as algaecide for many decades (Barrington and Ghadouani, 2008; Lusty and Gobler, 2020). I was able to narrow the H_2O_2 dose range, showing that less than 50 microliters H_2O_2 per 50 mL water sample was needed to effectively kill off the algae, and these results were passed on for future research. This experience was in the water sector of the Biological and Agricultural Engineering Department at the University of Arkansas, and it solidified my decision to get my degree in Biological Engineering (BENG).

Biological Engineering is a field that explores food, water, and energy systems and the nexus between the three sectors and sustainability. The degree program starts with hands on learning through a project designing and constructing an aquaponic environment to support an overpopulation of

goldfish (BENG 2632). The sequence of classes in this program build on applying engineering to biological systems, which is central to Biological Engineering programs (Johnson and Phillips, 1995). Other projects have included updating warehouse plans to be more energy efficient (BENG 3653) and constructing a pump-pipe system to move water from a reservoir of low elevation to a higher detention area (BENG 3723). These projects have allowed me to see my classroom knowledge in action while also gaining soft skills that come with submitting design deliverables and working in a team. Specific BENG courses which have most shaped my career path are included in Table 1 below.

Table 1. Courses that had significant impact on my career path while studying Biological Engineering at the University of Arkansas (Fall 2019 – Spring 2023).

Course (Semester)	Contribution to Career Interests
Biological Engineering Design Studio BENG 2632 (Sophomore Fall)	- Introduction to the food-water-energy nexus - First hands-on experience with project and engineering design process
Global Bio-Energy Engineering BENG 3653 (Junior Fall)	- Team experience with modeling in Excel - Individual experience with leading a team - Introduction to Engineering Economics
Unit Operations in Biological Engineering BENG 3723 (Junior Spring)	- Application of hydraulics and thermodynamics - Introduction to modeling complex water systems
Hydrology CVEG 3223 (Junior Spring)	- Introduction to stream restoration - Importance of floodplain modeling in public safety - Using equations to model water runoff
Sustainable Watershed Engineering BENG 4933 (Senior Fall)	- Application of Hydrology with storm water management model (SWMM) software - Introduction to designing low impact developments (LIDs)
Senior Biological Engineering Design I BENG 4812 (Senior Fall) Senior Biological Engineering Design II BENG 4823 (Senior Spring)	- In-depth group project spanning senior year - Applying engineering economics to surface water pumping systems for Bayou Meto Irrigation Project (large infrastructure project) - Working with consulting firm client - Collaborating with my team to plan tasks and make steady progress

In addition to courses and projects, it is important for engineering students to have real world experience to gain inside knowledge of various career paths; this can come in the form of internship experiences. Internships are considered as critical high impact practices (HIPs) by the National Survey of Student Engagement alongside research with faculty and service-learning opportunities. This means they both have positive impacts on student learning and retention. HIPs are classified this way because

they “demand considerable time and effort, facilitate learning outside the classroom, require meaningful interactions with faculty and students, and encourage collaboration with diverse others” (Kuh, 2008; “High-Impact Practices,” 2022). HIPs have several core components (Figure 1) that cause them to be classified this way (Pusca and Northwood, 2018).

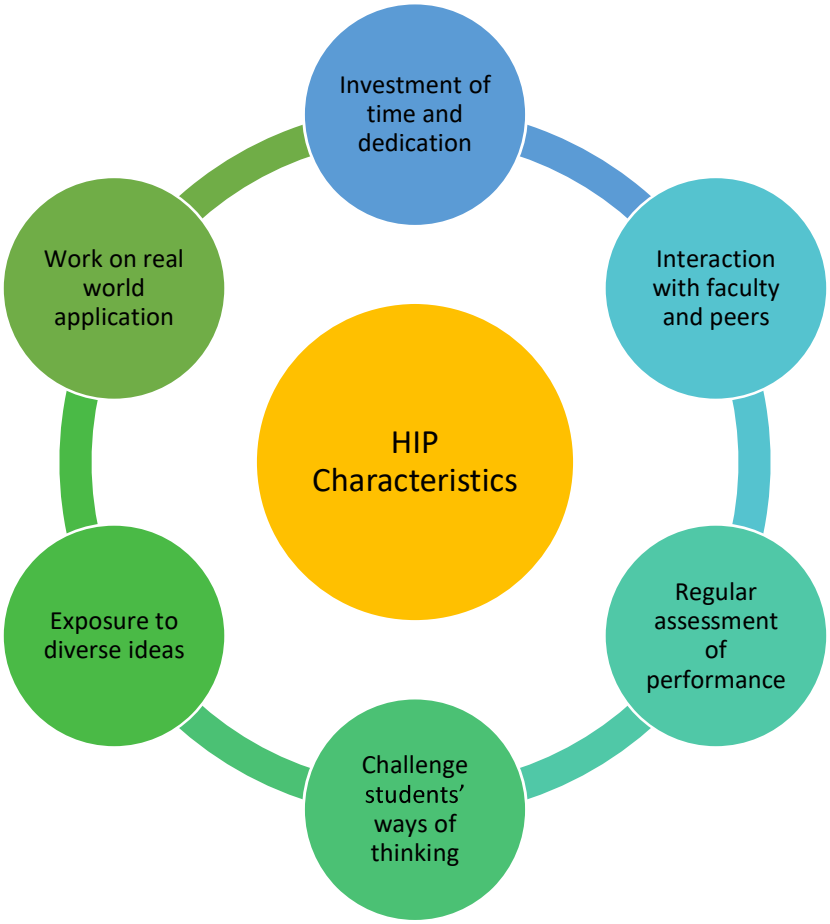


Figure 1. High impact educational practice components. HIPs do not need to contain all these characteristics to be classified as such. Figure is adapted from Pusca and Northwood, 2018.

Internships have been shown to improve engineering students’ comprehension of classroom concepts, and engineering students with internships have an early opportunity to explore sub fields of their engineering discipline and identify the best fit (Ozek, 2018). Many students receive full-time offers from their internship employer to return after graduation, and in general, other employers will highly

value industry-focused experience (Ozek, 2018). The learning intensifies after the concrete internship experience through reflective observation, abstract conceptualization, and active experimentation; these steps involve identifying areas where there are gaps between experience and understanding, considering new ideas that modify existing concepts, and applying new ideas to other experiences to see what results (Mcleod, 2013). Through active reflection, knowledge gained becomes internalized and can be applied in future opportunities. This cycle can be seen in Figure 2.

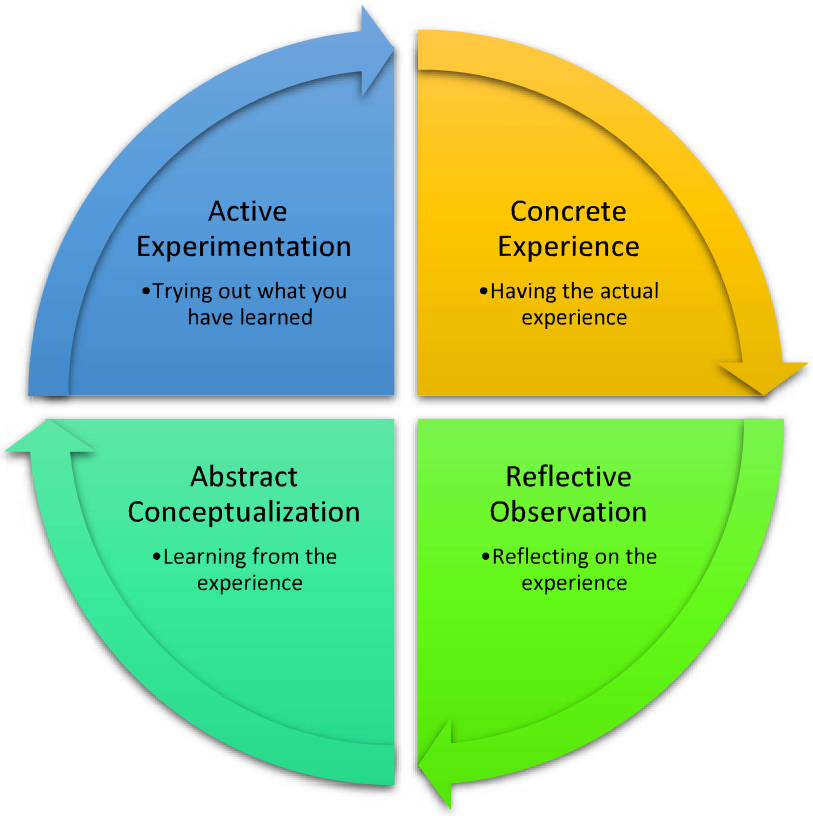


Figure 2. Illustration of Kolb's learning cycle adapted from Mcleod, 2013.

To explore my career interests, develop personal and technical skills, and improve my employability, I chose to complete three separate internships (Table 2). These experiences, along with my coursework, have allowed me to learn what sub field of Biological Engineering I wish to pursue and

develop a variety of technical and soft skills that lend themselves to becoming a productive, professional engineer.

Table 2. Internships completed during my undergraduate degree program.

Internship	Dates
Arkansas Water Resources Center Water Quality Lab Intern	January 2021 – May 2022
Public Water Utility Environmental Intern	June 2021 – August 2021
Consulting Firm Water Process Mechanical Intern	June 2022 – August 2022

Another significant component of my undergraduate experience has been the honors college and engineering honors programs. Honors programs have historically been shown to improve final GPAs, retention rates, and general engagement in participating students compared to non-honors students. Reasons cited for these improvements include priority registration, program prestige, connection to honors college faculty and peers, and supplemental opportunities, such as research and travel, for honors students (Rinn and Plucker, 2019). The University of Arkansas provides similar benefits to honors college students, and the College of Engineering Honors Program provides a structure for student and faculty collaboration. There are many academic and career planning sessions and scholarship and grant programs available exclusively to honors students. As a member of the honors college, I have been able to register for Honors University Physics 1 (PHYS 2054H) and Honors Measurement and Control (BENG 3113H). Both classes featured an extra project for honors students which extended slightly beyond the regular course material and required independent thinking. My experience with the honors college has also included receiving funding for a study abroad program through the American Institute of Foreign Study called “London: Sustainable City?”. Through this program, I visited London and explored sustainability initiatives which allowed me to witness the theory

from my sustainability coursework in action. Furthermore, the support I have received from the honors college through academic and career planning sessions as well as scholarships has been very valuable.

Honors college students end their undergraduate studies by completing an honors thesis. This is a project that may be outside of their degree requirements and culminates in a paper discussing the body of work and significance. Traditionally, most engineering students will complete a research or design project in a field adjacent to their degree plan with a mentor to guide them in the process. However, in recent years there has been a push to allow alternative thesis formats, such as the creation of a video about climate change and engineering solutions (Oakley, 2022). Since internship experiences are recognized as HIPs and the honors thesis is designed to be a gateway to work beyond the typical undergraduate degree, I helped develop a pathway for BENG honors students to use critical reflection to develop an honors thesis related to internship and class experience.

Objectives

My objective for this thesis was to describe the value of my engineering and technical internships and coursework and how they have shaped my future career in Biological Engineering. I highlighted class projects that are relevant to my career goals and critically reflected on the relationship of my coursework, honors experience, and outside the classroom learning. This provided an example thesis for honors students in Biological Engineering and the College of Engineering that want to complete their thesis requirement through internship(s) rather than traditional research and design experiences. Additionally, I developed a framework for future honors students to evaluate their own undergraduate and internship experiences and consider their career paths. This will add value to the engineering honors college program, making it more inclusive of students that want to pursue industry careers rather than higher education and invest their time into internships rather than research. The

final product was a guide for using reflection to develop an honors thesis related to internships and coursework.

Methods

To reflect on my internship experiences, I developed a list of questions to ask myself in four categories: background information, learning objectives and goals, personal experiences, and reflection. These were inspired by my research about the experiential learning cycle (Mcleod, 2013) and the Model of Internship Thesis document from the University of Arkansas' Walton College of Business Accounting Department (Sam W. Walton College of Business, 2023). These topics and questions included:

- Background Information
    - How did I find this job? What services does the company provide? Who are their typical clients? Do they have a common type of project?
- Learning Objectives & Goals
    - Why did I take this job? What was I hoping to gain, learn, and explore?
- Personal Experiences
    - What role did I perform? What were my daily tasks? What were some specific tasks and projects that I got to work on, and what was the importance?
- Reflection
    - What did I most enjoy about this internship? What did I least enjoy about this internship? What technical things did I learn? What general skills did I gain? How did the things I worked on connect to my previous professional and academic experiences? How did the concepts I learned guide and assist my future experiences and goals (i.e. FE exam, classes after internship)? What about this experience led me to apply to my next internship or job opportunity?

I had a brainstorming session for each internship before I began writing about it in which I asked myself each question and wrote down any ideas and examples that came to mind. In my process, I referenced documents from my internships, including an old time log and lab bench sheet to remind me of my role. While I did not have a significant answer to every question, I was sure to include some discussion for every category of question. Next, I organized my answers and used them as an outline for drafting an analysis of each internship; I allowed myself to add in new discussion points that came to me as I was writing.

Once I completed the three internship writeups, I started to look for common themes about what I learned and what skills I developed at each company. I wanted to have at least three big picture takeaways from my internships to emphasize to my readers in a summary. Once I decided on my takeaways, I went back through and included additional information to highlight them. Finally, I formed larger conclusions about the impacts of internship experiences on my college experience and future career path.

Results

Internship 1 – Arkansas Water Resources Center Water Quality Lab Intern

The Arkansas Water Resources Center (AWRC) in Fayetteville, Arkansas is a water research institution affiliated with the University of Arkansas and the Division of Agriculture. It serves to help manage Arkansas' water resources by collaborating with local, state, and government agencies to further water research, train future water scientists, and relay information to stakeholders (AWRC, 2023a). It houses a water quality lab, managed by Dr. Brian Haggard, which analyzes water samples from across the state. Clients range in size but include many individuals, such as farmers that want to test their livestock and poultry water supplies and landowners that want their well water or fishponds tested. The AWRC offers affordable packages, starting at $65 for a livestock analytical package, to

ensure these services are available to those that need them (AWRC, 2023b). The advertised costs are for individual analyses for one sample, but costs can be reduced when analyzing multiple parameters or samples.

After my project with Dr. Haggard my freshman year, I was offered a job at the AWRC working within the water lab. I chose to accept the job to learn more about water quality monitoring and engineering careers that relate to water resources. This was also my first job, so I was hoping to gain general employment experience to show that I was a dependable worker and would be a good candidate for future opportunities.

My general tasks included providing support to the lab with tasks that they were behind on, like labeling sample bottles before collection and acid washing them once the sample was processed so bottles could be reused for the next collection. My main task in this role was reviewing quality assurance and quality control (QAQC) reports from the lab to ensure that results from water quality tests were accurate. Each time the lab runs a test for a water quality parameter, standards of known values are also included to screen for issues such as faulty equipment calibration or human error. QAQC reports are generated for an outside reviewer, who did not complete the lab testing, to look at and ensure data for the standards falls within the acceptable margins of error set by the lab.

Figure 3. Me using a pipette in the AWRC water quality lab on April 30, 2021.

In this role, I learned the importance of quality control procedures, especially within organizations like the AWRC that provide lab services to the general public, who may rely on this information to inform public health and safety decisions. I also enjoyed the hands-on aspects of the job within the lab. I gained confidence in my ability to use lab equipment, including micropipettes, precision scales, a filter apparatus, personal protective equipment, and a drying oven, which translated to future lab courses, including General Microbiology (BIOL 2013) and University Chemistry II (CHEM 1123). However, some tasks became repetitive in my role, leading me to discover that I want to work in future roles that touch a wider range of tasks and projects.

I started this job two months before the pandemic hit Arkansas, so another lesson I learned was the importance of having an organized procedure for collaborating on digital files. Previously, reviewers would look at physical copies of lab results to verify, but a fully online procedure was needed to move forward. With some trial and error, the lab adapted to work with a file sharing system in Box, which is a tool that I became proficient in and have since applied to manage documents in my senior design class (BENG 4823).

More broadly, this job introduced me to the concept of non-point source pollution, which occurs when components such as organic matter and fertilizer wash off the landscape and into waterways, creating an excess of nutrients in the water supply. Combined with certain environmental conditions, nuisance and harmful algae can grow exponentially, causing aesthetic issues and potentially making water unsafe for recreation and drinking water supply. Reducing runoff from the landscape and monitoring water quality over time are necessary for ensuring a safe water supply for future generations. The AWRC makes an impact by providing information about water quality across Arkansas' streams, rivers, and lakes, and other organizations can use this data to decide where to focus environmental rehabilitation efforts.

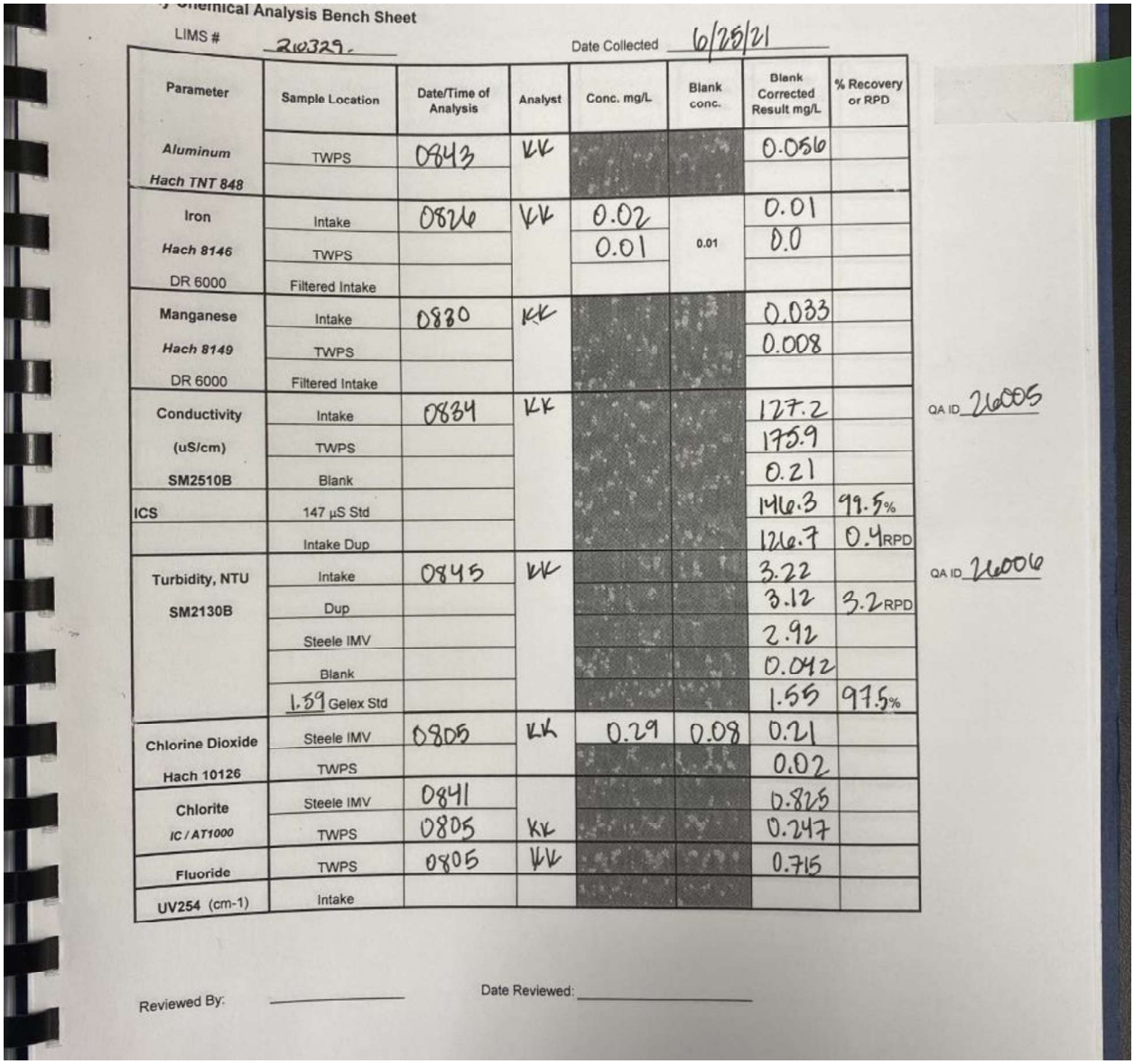
The concepts of non-point source pollution and its effects on the environment as well as water chemistry practices from the lab are reflected on the Environmental Fundamentals of Engineering (FE) Exam, which includes a section on "surface water resources and hydrology" and "environmental chemistry" (NCEES, 2020). I also was required to complete safety trainings and wear personal protective equipment, which is in line with the "health hazards and risk assessment" section (NCEES, 2020). Overall, this internship experience did meet my objectives, helped me prepare for future courses and the FE, and led me to search for other internships and experiences to prepare me for a career in water resources engineering.

Internship 2 – Public Water Utility

Spring of my sophomore year, I started to search out internship opportunities in the water industry. The Biological and Agricultural Engineering Department regularly sends out postings that they receive for internship and job opportunities in related fields. They sent out a listing for an environmental intern position at a public water utility that has a focus on conservation and resource management. The utility receives water from a local, freshwater lake and treats it to meet drinking water health and safety standards established by the Arkansas Department of Health (Arkansas Department of Health, 2023)

and the Environmental Protection Agency (Environmental Protection Agency, 2022). From there, potable water is delivered to customers for many uses including drinking, cooking, bathing, and industrial processing. The duties from the posting included a mix of indoor water lab work and outdoor water quality sampling activities. I applied with the goal to learn more about engineering drinking water treatment processes, experience a hands-on role, and explore a career that involved some outdoors work. I also knew I would be a competitive applicant due to my previous internship in the AWRC's water quality lab.

Each morning, I went to different points along the plant, from the intake on the lake to finished water entering the clearwell for storage and collected water samples from taps. Then, I brought them back to the lab and ran a set of tests for aluminum, iron, manganese, conductivity, turbidity, chlorine dioxide, chlorite, and fluoride. Next, I entered my results into the Library Information Management System, or LIMS, which showed the maximum allowable standards and flagged any results that did not meet regulatory requirements. I have since learned that LIMS is broadly used by many labs, including the AWRC water quality lab. I also helped to perform quality control on other coworkers' results, ensuring that results were entered correctly into LIMS and met regulation. This company, like the AWRC, checks water quality for sources strongly linked to human health and safety. Therefore, they also placed an emphasis on QAQC practices to minimize lab and human errors. Other regular tasks in the lab included acid washing glass dishes after they were used for tests to prevent contamination of future results. Overall, the lab component of this internship was very similar to my internship at the AWRC, and I was able to expand my lab responsibilities as I gained new skills and experience.



Chemical Analysis Bench Sheet

LIMS # 210329 Date Collected 6/25/21

Parameter	Sample Location	Date/Time of Analysis	Analyst	Conc. mg/L	Blank conc.	Blank Corrected Result mg/L	% Recovery or RPD	
Aluminum Hach TNT 848	TWPS	0843	KK			0.056		
Iron Hach 8146 DR 6000	Intake	0826	KK	0.02	0.01	0.01		
	TWPS			0.01		0.0		
	Filtered Intake							
Manganese Hach 8149 DR 6000	Intake	0830	KK			0.033		
	TWPS					0.008		
	Filtered Intake							
Conductivity (uS/cm) SM2510B	Intake	0834	KK			127.2		QA ID 210005
	TWPS					175.9		
	Blank					0.21		
ICS	147 µS Std					146.3	99.5%	
	Intake Dup					126.7	0.4 RPD	
Turbidity, NTU SM2130B	Intake	0845	KK			3.22		QA ID 210006
	Dup					3.12	3.2 RPD	
	Steele IMV					2.92		
	Blank					0.042		
	1.59 Gelex Std					1.55	97.5%	
Chlorine Dioxide Hach 10126	Steele IMV	0805	KK	0.29	0.08	0.21		
	TWPS					0.02		
Chlorite IC / AT1000	Steele IMV	0841	KK			0.825		
	TWPS	0805				0.247		
Fluoride	TWPS	0805	KK			0.715		
UV254 (cm-1)	Intake							

Reviewed By: _____ Date Reviewed: _____

Figure 4. Daily bench sheet results for samples taken from taps throughout the plant. Quality assurance (QA) practices built into the bench sheet included performing duplicates (Dup) and finding the relative percentage difference (RPD) and testing standards (Std) to see how close the results were to known values (% difference). Only conductivity and turbidity parameters required these analyses. Results were entered into LIMS with the QA IDs on the right side.

Once a week, I went out with the environmental division personnel to sample from a boat. We collected samples at predetermined locations throughout the lake to establish long-term data upon which they can derive normal ranges for water quality parameters. I learned that lake water quality changes significantly with different locations, seasons, and weather conditions. Monitoring all these

changes over time allows for prediction of what source water conditions may be at a specific time and place in the future. It can also help identify deviations from normal conditions. For example, some sampling areas tended to have higher nutrient levels in the water than others due to greater organic matter being deposited into the lake near that location. However, if a sample from a generally lower area suddenly spiked, there would be cause to search out the factor that is causing the abnormal nutrient load. Overall, collecting information on the background water quality of the lake can be useful for making decisions and modifying treatment schemes within the plant. This information can also help protect the source water, which is good for the environment, community, and water utility's economic interests.

Figure 5. Me driving the boat for the environmental quality team at the end of a sample run on July 6, 2021.

The environmental team also collected a profile each week at the intake, taking samples every few meters down from the surface to the lake bottom. Through this process, I learned that lake water is not homogenous and changes significantly with depth because of lake stratification, which is when lakes thermally "divide" into different layers of water that do not mix. The top layer of water, called the epilimnion, is warmed constantly by the sun, decreasing its density, and keeping it afloat. The coldest, lowest layer of water is called the hypolimnion; it also contains the least dissolved oxygen since it does not interact with the surface, where oxygen is dissolved into water from the air and generated through

photosynthesis by some aquatic organisms. Between these layers is the metalimnion, which is a transition zone between the hottest and coldest layers (Paul Fafard, 2018). Understanding the interactions between the lake layers and the condition of the water at the intake depth also helped guide plant operation decisions.

I really enjoyed the opportunity to go out sampling events and decided that I wanted to have a career that would include site visits and chances to get out of the office. I gained even more laboratory skills like working with a vent hood, centrifuge, and LIMS. I also learned a great deal about the chemical and mechanical processes that are required to treat water from start to finish, which has helped to prepare me for "fluid mechanics and hydraulics", "environmental chemistry", and "surface water resources and hydrology" FE concepts (NCEES, 2020) as well as my junior year courses Hydraulics (CVEG 3213), Hydrology (CVEG 3223).

Another concept that I was introduced to is "engineering economics" (NCEES, 2020). Potable water is needed to make an area inhabitable and economically viable. The public utility is responsible for determining how to treat and provide water at an affordable rate, and the company must decide on a rate structure that makes sense for their customers and the needs of the community. If water is too expensive, companies will move in favor of cheaper rates. However, if water is too cheap, customers may overuse water, depleting source water or surpassing plant capacity.

While I did feel that my degree was adequately preparing me for this type of career, this internship focused primarily on environmental science and chemistry concepts, and I really wanted the opportunity to further explore engineering specific applications that I was learning in my Biological Engineering program. This internship, along with my previous one at the AWRC, could be classified as lab technician positions. While lab technician positions are very important and require running experiments and collecting data that is used to make good engineering decisions, they do not have the responsibility of

continuing into the engineering work. While I am glad to have a background as a lab technician to understand that work that goes into monitoring complex engineering systems, I know now that I want to focus my career on the engineering side. The job could also be physically demanding, requiring me to be on my feet all day and have some exposure to chemical irritants. Therefore, I decided that I was still interested in the water sector of Biological Engineering, but I wanted to find a career that was less lab oriented, and more engineering focused.

Internship 3 – Consulting Firm Water Process Mechanical Intern

Throughout my junior year, I started to think more seriously about what type of career I wanted after graduation. I researched companies that were recruiting engineering students from my major and made a list of my top choices. I decided that I wanted to apply to engineering consulting firms that worked on projects in the water and wastewater industry since I identified this as a field with many job opportunities. Also, many alumni of my department have gone on to successfully work in water and wastewater roles, including three individuals at the company where I ultimately accepted an internship. I was placed on the process mechanical team, which is responsible for design, calculations, modeling, equipment sizing, and overseeing construction related to building new or upgrading existing water and wastewater treatment plants, though during my internship all the projects I worked on were for wastewater treatment plants. My goals for this internship were to gain engineering focused experience, apply knowledge I learned in my junior year engineering classes, learn more about the consulting firm environment, and determine if the company might be a good fit for me in a future, full-time role.

In this role, I was assigned a mentor that I met with daily to determine what I would be working on. Many of the tasks that I was given were to supplement the projects that she was working on at that time; she would also tell me about her work for the day and how it fit in to the overall project. Our system allowed me to work on a variety of tasks and learn more about the company's process for completing projects, in which they turned in internal submittals at 30%, 60%, 90%, and 100% of the

planning process. This facilitates the employees staying on track with progress and ensures that work is completed in a logical sequence. Each submittal is sent to an internal QAQC team that is responsible for finding errors in the work before it is sent to the client. The company emphasized that it was important to them to provide a high quality of work to their clients, so they always ensured that there was enough time for QAQC to review their work, send it back with comments, and approve the edits before any external project deadlines.

Many of the tasks I worked on involved using Excel. A specific project that I worked on was in the phase of deciding which equipment to use for a future wastewater treatment plant. I was responsible for going through the equipment information sheets sent by different manufacturers to find differences in equipment specifications to aid in decision making. I created sheets to compare different types of equipment, including pumps, valves, screens, and grinders. During this time, there was also significant inflation occurring in equipment and material prices. Therefore, I was responsible for emailing manufacturers to get updates from the quotes that they had sent us 3 months prior, and I changed them in project budget sheets.

Another program that the company used was Bluebeam, which is a software that allows for organizing, viewing, and collaborating on a set of engineering plans. CAD technicians begin by drawing plans in AutoCAD and uploading them to Bluebeam; then, engineers can leave comments and markup the drawings to communicate things that need to be changed in the CAD files. Frequently, my mentor would request and receive back edits on a set of plans and then send them to me to backcheck, making sure all her requests were fixed in the new set of drawings. Towards the end of my internship, I had learned enough from looking at the errors my mentor commonly found to start marking up primary plans on my own, finding mistakes like missing labels and extra lines. Then, I sent the plans and comments back to the CAD technicians to be fixed. From there, the technicians sent an updated version to an engineer for a more thorough, secondary review.

My biggest project of the internship was creating a tool that generated pump curves automatically. The user could input pump performance data from the manufacturer, including flow and total dynamic head, for up to three different pump types. The user also selected how many of each pump type was operating. My tool was able to generate pump curves for the chosen pumps and quantities working in parallel, which is when the pumps are working together and increasing the flow through the plant, but the total head is not increased. This tool was intended to help engineers size pump needs when adding pumps to existing pump stations at water or wastewater treatment plants. Many water and wastewater treatment plants were built when city populations were smaller so there is a need to be scaled up by adding new pumps to meet increased demand; therefore, having a feature to model the impact of adding different varieties and quantities of pumps made the tool highly useful. Pump curves can be graphed alongside system curves made from plant data, which illustrates the amount of increase in head through the plant as flow increases. Where the system and pump curves intersect is known as the operating point. The operating point describes how much flow will actually be achieved by the pumps and pushed through to the plant and how much head can be expected at that capacity (Figure 6).

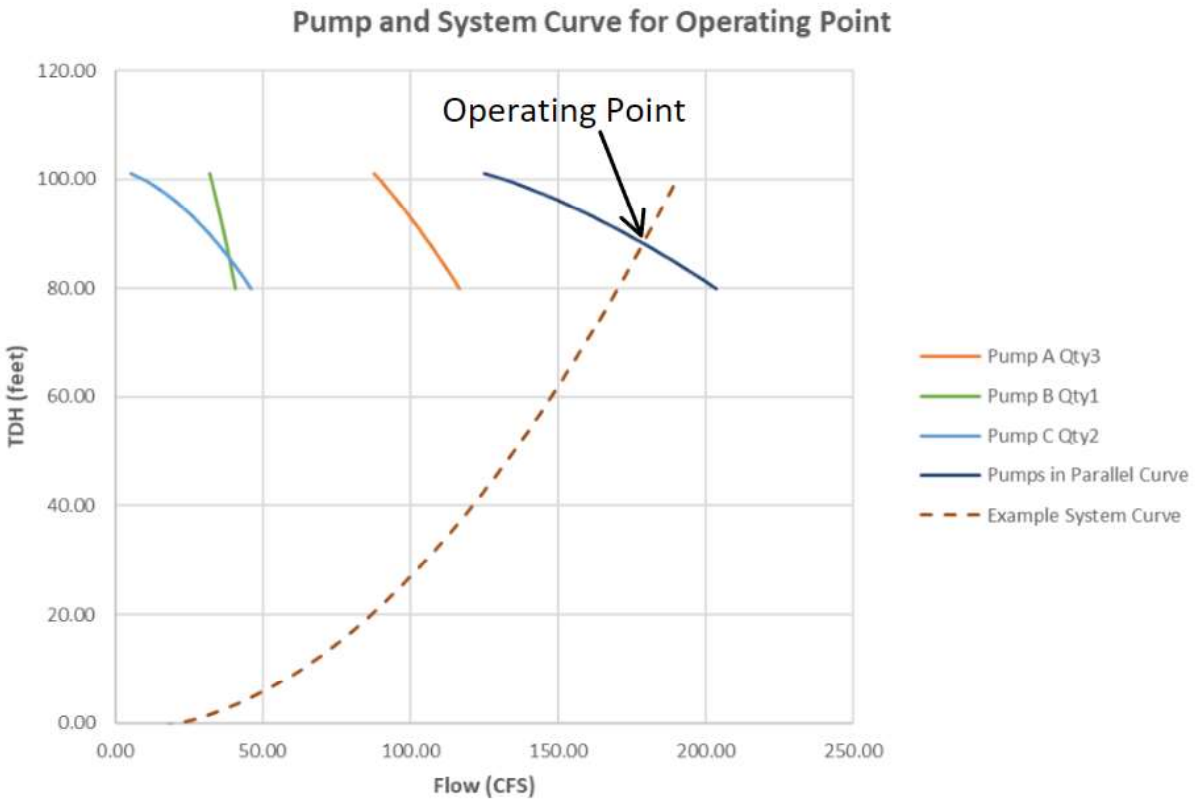


Figure 6. Example pump curves, pumps in parallel curve, and system curve to determine operating point of a wastewater treatment plant.

I learned about pump curves, system curves, and operating points in my Unit Operations class (BENG 3723), and my internship mentor and I came up with the idea for this tool after she had me make pump curves for one pump at the beginning of my internship. We decided that I could work on automating the process in this project on days that she did not have other work for me to do. By the end of the internship, my tool was functional and able to be passed off to the team for use.

More generally, I got to attend team meetings and learn about the workflow of this consulting company. I enjoyed seeing how new projects were brought in and assigned as soon as old ones were completed and sent off for construction. I also liked seeing how the engineers were not afraid to ask for help when they ran into problems and how they could effectively but concisely communicate their progress each week. Overall, I found that I liked the consulting environment because the variety of

projects being pursued, and the faster pace of progress kept things interesting and allowed me to learn something new every day. I also enjoyed that there were many young engineers on our team that remembered what it was like to be an intern themselves. I felt very comfortable approaching them with questions, and they were happy to go the extra mile to teach us new skills. I did appreciate the good that wastewater treatment projects provide to the community, allowing for population and economic growth while preventing harm to the environment that would occur if need surpassed treatment capacity and contamination occurred. It was also interesting to see engineering economics at work when the team was trying to find cost-effective solutions to meet the client's needs and budget.

There were also some aspects of the job that I did not like and ultimately led me to not return. Firstly, I learned that I do not want to work in a role that is mechanical engineering focused. I did not enjoy learning about the specifics of valve and pump functions to size them for plants, which is a frequent task for engineers on the team. I also discovered that I do not find the biological, chemical, and mechanical specifics of wastewater treatment processes to be as interesting as stormwater, hydrology, and water resources engineering concepts that I was introduced to in my classes (BENG 4933, CVEG 3223) and previous internships. Therefore, with these things in mind, I chose to seek a different role for my first, full time job following graduation.

Future Career

I have accepted a role with a land development consulting firm. This will involve grading sites and developing plans to deal with water that falls on properties that are being developed to minimize negative impacts on local hydrology such as stream erosion and flooding. I believe that it will combine many of the things I enjoyed from each internship, such as being on a team with many young engineers, having a mentor, and learning new computer software. I am excited to begin my career and am grateful

that my three internship experiences allowed me to find out what kind of work I find fulfilling while pursuing my degree.

Summary and Conclusions

One key takeaway from my internships was the importance of checking work through a formal QAQC process. All three internships involved a review process before sending out work to clients in order to ensure public safety and to maintain trust and reputations with their clients and stakeholders. Another important revelation was that there any many types of careers and paths to make an environmental impact. All three of my internships involved protecting water resources from pollution. A third common theme was the importance of engineering economics. If solutions are not affordable, they cannot be adopted, so economics is vital to any company or project.

Overall, each of my internships met my learning objectives and allowed me to gain insight into three different career paths that biological engineers are qualified to pursue. I was able to discover that I prefer a career in a consulting environment over a laboratory and solidify that I want to work in water-related engineering. My internships went hand in hand with my coursework to solidify concepts I had learned in previous classes or introduce future class and FE exam topics. Furthermore, I grew technically by learning about Excel, LIMS, and Bluebeam, and I developed professionally by witnessing different management styles and networking with many water professionals.

Methods Discussion and Recommendations for Thesis Pathway

Since internship experiences are recognized as HIPs and the honors thesis is designed to be a gateway to work beyond the typical undergraduate degree, I helped develop this pathway for honors students to use critical reflection to develop an honors thesis related to internship and class experiences. While an honors thesis should look different for every student, I believe my methods will

be a helpful example to build upon. I found the discussion questions presented in my methods section to be very useful in writing my thesis, but I can think of some ways to add to and improve the process.

Though I had three internship experiences to discuss, I think this process is still an honors worthy endeavor for a single internship reflection. However, I believe writing a thesis about a single internship experience would need to include more in-depth planning and discussion. For example, it would be helpful to write the background section and learning objectives and goals section before the internship begins. It would also be good to journal weekly throughout the internship to discuss progress on learning objectives and new skills that are being built. It was difficult to think back on experiences from years ago and recall my learning goals and key takeaways without much documentation. Furthermore, engaging in weekly reflection would enhance learning and recollection of skills from the internship.

Another component that I recommend future students add is suggestions for improvement of the curriculum. My committee members, all faculty at the University of Arkansas, expressed an interest in how the curriculum could be adapted to support industry-focused students like me. Therefore, students should discuss how coursework helped prepare them for their internships and comment on any gaps that should be filled to better prepare them for their careers. Good discussion questions to add would be “how did the curriculum prepare me for this internship? What do I wish I had known before starting my internship? Do I feel prepared for my future career? If I could add or remove a class from my degree plan, what would I choose and why?”

After delivering my thesis defense, it was suggested that I compare my methods to other examples and note where improvements could be made. I was able to connect with Annelise Koster, a student in Data Science at the University of Arkansas, who had a similar approach in writing her honors thesis about one internship. She chose to include six sections: company background/history, description

of role, learning goals, project description, and a journal entry from each day/week of her internship (Koster, 2023). Reading through her thesis, I noted that she had set her personal learning objectives before the internship and journaled throughout. Both were helpful in framing her thesis since she documented as she progressed through tasks and could remember the parts that gave her trouble and how she worked through them instead of just remembering what she had accomplished at the end. I also liked that she discussed a specific project she worked on throughout the summer and provided numbers and figures to explain her technical reasoning. Especially with single-thesis internships, this level of detail is helpful for showing growth. Another thing that she included was a table of contents, which would be helpful for organizing the thesis. Future thesis students should also consider examples of how universities like MIT, Purdue, and Stanford encourage their engineering students to reflect on internships.

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