

A Reflective Journey: Navigating Your Cumulative Experience at Iowa State University

As I get closer to finishing my undergraduate degree at Iowa State University, Reflecting on the conclusion of my undergraduate education at Iowa State University, I have found myself thinking about how I have changed compared to the beginning of my education at Iowa State University. Back then, I thought that being proficient in engineering was about knowing formulas, following certain steps and arriving at correct answers. Although I still appreciate the technical aspects, my experience at Iowa State has shown me that engineering includes more than just that. It involves problem-solving skills, learning to communicate with others, adjusting to failure, considering wider implications of engineering and learning throughout your life.

One of the major aspects that I have improved at Iowa State University is my approach to engineering problems. At the early stages of my academic career, my attention was focused on individual calculations like calculating the voltage, solving equations and making sure that the circuits worked correctly. Moving to the upper-level electrical engineering classes, I started considering full systems and interaction of their elements.

Control systems became especially important in my transition to a broader view of engineering. In the control systems class, I dealt with mathematical models, system response, feedback, stability and state space representation of systems. At the beginning, many of these ideas felt like abstract mathematics. Through simulations and design problems, however, I started seeing what the equations represented physically. Changing a controller parameter was no longer just changing a number in an equation. It could change how quickly a system responds, whether it overshoots, or whether the system remains stable.

Many of those concepts appeared to have been like abstractions of mathematics at first glance. However, through simulations and design problems, I learned to see how those equations worked in reality. By changing one of the control parameters, for instance, one might change the speed of the system, its tendency to oscillate, or affect stability in general.

I keep building on that foundation with my current course on linear systems. The topics include the state-space approach, stability, controllability, observability, state feedback, and estimation. Enrollment into the course itself was an educational experience too since I enrolled late in the semester. That is why I had to go back and fill in the gaps in my lectures and assignments, while everyone else kept moving forward. I worked with my professor, teaching assistant, and study group, while also reviewing the materials independently. It showed me that learning is not always done in perfect conditions; it requires seeing the gaps in one's knowledge, finding the necessary materials, and working on them alongside other commitments.

The senior design project, PV-ALPHASync: Intelligent Lab Automation & Analytics for Next-Generation Semiconductors, gives me another chance to utilize these skills in an engineering setting. However, the project is still ongoing. Planned activities for the current semester and the next one include attempts to incorporate the elements mentioned above into

an integrated process. In other words, all tasks should be optimized in such a way to make the whole workflow more efficient.

For the current semester, the project has already started using Python programming and experimental data related to solar cells for revealing techniques that could simplify the processes of data analysis and summarization. Currently, a task that is being accomplished involves developing a technique for analyzing data from several solar cells in order to obtain such characteristics as open circuit voltage, short circuit current density, fill factor, and power conversion efficiency. However, considering the developmental stage of the project, the main objective is to understand the relationship between the code used, the raw data collected and the experimental procedure itself.

Although the project is still in an early stage, it clearly demonstrates how many engineering disciplines could be interconnected. It is important not only to understand how programming works but also to understand electrical measurements and their meaning. Even if the code does not contain any errors, it can result in nonsense if calculations in it are based on wrong engineering knowledge.

As the next semester starts, it is expected that the project will move closer to the development of an integrated system that would include measurement setups, control software, data storing and visualization as well as analysis. The process will undoubtedly involve a lot of troubleshooting and debugging. Although the final results have not been achieved yet because of the developmental stage of the project, it already shows its capability to provide students with a more complex engineering problem.

PV-ALPHASync has provided insight into what engineering automation really means outside of textbook cases. The overall goal goes far beyond just automating one specific calculation. It involves thinking about measurement techniques, data organization, data analysis, and user interaction. A project such as this requires an approach that considers hardware, software, data, and users as parts of one united system.

Working with photovoltaics and semiconductors has increased my awareness of the socio-economic and environmental aspects of engineering as well. Working with renewable energy technologies is part of a larger task of creating alternative energy sources. Improvements in the fields of semiconductor materials, devices, their properties and characterization, and research efficiency can help create new energy technologies. While my personal contribution to this is a very tiny part of the overall process, I have learned that engineering research can serve environmental purposes.

Economic aspects are also important in this project. Automated repetitive measurements and data analysis can save researchers' time by eliminating tedious routine work. A more advanced system can be used for easier comparison of results, problem detection, and efficient laboratory work. My views on efficiency in engineering have been redefined – improvement of a process may mean not only increasing speed of a device, but also cutting down unnecessary efforts, increasing consistency, and being able to focus on analysis and design.

Such experiences have helped me realize that engineering decisions do not happen in a vacuum. Engineers can design something technologically sophisticated, yet the decision needs to be practical, reliable, safe, and useful for its users. In other words, a technically brilliant solution can be a bad engineering solution if it is too expensive, wasteful, risky, or impossible to implement by users. Engineer ethics introduced me to some additional factors that affect engineering decisions. Before studying this course, I always focused on whether something works. Now, I know that engineers need to consider who and what are impacted by their decisions and what are the consequences of certain actions. Such factors as safety, environmental impacts, cost, reliability, accessibility, and unintended consequences should be taken into account.

Such aspects can also become global in nature. For instance, technologies, which are created in a specific place, can be used by another group of people in other places and with other resources, infrastructure, and requirements. The solution that is appropriate for the initial environment does not necessarily suit others. It has become obvious from my coursework that engineers are unable to completely separate the technical decisions from people and environments impacted by them.

Another big shift during my years in college was connected with information search. At the beginning of my education, I used lectures, lecture notes, books, and in-class examples. However, as the tasks were getting more complicated, I understood that the classroom information is just a start point.

Now, I use datasheets, technical documents, research papers, software documentation, my professors, teaching assistants, classmates, and other technical sources when I need to learn something new. I have done it while working with Python, MATLAB and Simulink, circuit components, semiconductor processes, and other engineering instruments.

Currently, my senior design projects show how the process of finding additional information is essential. Learning existing codes in Python and photovoltaic data requires me to go beyond the single class. I need to know the structure of the program, data organization, what each parameter in photovoltaics means and how similar characterization problems can be solved. I have not learned some of them yet; however, it becomes obvious that the ability to find and comprehend new information is the skill of an engineer.

The projects done personally help me to acquire such a skill. When I work with electronics and investigate the circuit or the device, there is no professor telling me the whole step-by-step list of instructions. I have to examine the schematics, technical characteristics, documentation, and examples and combine all these pieces of information. There can be situations where the initial decision fails and I have to solve it. Such experience shows me that independent learning is an integral part of engineering, but not something that I need to do for some class assignment.

As my learning strategies have changed, my ways of solving problems have also evolved. During the first years in college, I focused on remembering the procedure of solving example problems. If I met any problem that seemed to be similar to the example, I could easily solve it.

However, the approach stopped working during upper-level engineering classes, because of the necessity to understand the problems and unusual way of presenting them.

Now, when I meet the problem, I try to identify its nature and concepts involved in it. I relate them to the familiar information and identify information gaps. Further, I fill these gaps using lecture information, external references, simulations, and discussion with other people.

Moreover, I realized that the ability to explain a concept or a process is a great way to test my understanding of it. I can calculate using mathematics, but the inability to explain why I am performing a certain action means that I do not understand the concept. It is especially helpful to discuss a problem with my classmates as discussing it requires me to explain my logic and thoughts verbally.

Simulation became another important aspect of learning as it allows comparing the theoretical predictions of a process with the simulated response. In controls, it helped me develop an understanding of the behavior of the system as it was easier to see the effect of changing certain parameters.

One of the things that I would change in my past college experience if I were starting it anew is building consistent study habits earlier. I would also try to seek help earlier. At the beginning of my studies, sometimes I tried to solve problems on my own as I thought that I should have been aware of their solutions.

I learned that engineering does not work that way. Every engineer lacks certain knowledge as there are always new things to learn. The ability to recognize when additional sources or help are needed becomes a part of solving the problem. Professors, teaching assistants, my teammates, the documentation, and other engineers can be used as such sources of information and not the last resort.

Moreover, I would explore control systems, automation, and programming earlier in my studies as these fields have always interested me the most. I enjoy problems where mathematics, software, hardware, and physical systems come into play. As a result of my studies in control systems and my current work in laboratory automation, I realized that this is the kind of problem I like to solve.

The experience at Iowa State University has also taught me the importance of effective communication. Engineering is not usually done by an individual and the Senior Design Project showed me that we depend on our teammates. I cannot expect that everyone in my team will automatically understand my progress and my approaches. I have to explain my results, document my decision-making, listen to the others and be ready to change my approach if someone comes up with a better idea.

It also changes depending on the audience. The way in which I explain my control system or photovoltaic measurements to my electrical engineering student teammate is going to be very different from the way I explain it to non-engineers. The ability to explain technical information

effectively is another skill that I want to continue improving because even the best technical solution becomes useless when nobody understands it.

Considering my career after Iowa State, I am mostly interested in control systems, automation and robotics. I want to improve my knowledge of control theory and become a better programmer. My work in PV-ALPHASync is also showing me the possibilities of software and automation in engineering laboratories and workflows. During this project, I want to gain more experience with experimental data, automation software and large engineering systems.

I am also interested in learning more about embedded systems, real-time control, autonomous systems, machine learning and industrial automation as these fields combine many skills that I developed during my studies.

I know that my graduation does not mean that I stop learning. On the contrary, my college experience taught me that engineering knowledge grows incredibly fast. There will always be new software, hardware, algorithms, manufacturing processes and technologies during my career. I am going to have to read documentation, learn new systems, communicate with experts and learn new skills far beyond the end of my studies at Iowa State.

In general, I think that the greatest difference between my experience at the beginning of my college and now is that I became more comfortable with not having immediate answers. When I started college, I felt bad about not knowing the solution of a certain problem. Now I understand that uncertainty often is the beginning of engineering.

The experience at Iowa State has taught me how to take the problem that I do not fully understand, divide it into smaller parts, use the available resources, test different options, learn from mistakes and go further. I came to Iowa State University to learn how to solve engineering problems. Instead, I have learned how to continue learning despite the fact that I do not know the solution. I believe that this ability will be the most important thing I take with me into my remaining semesters at Iowa State and into my career as an engineer.