<u>Reflection Draft 2: Power Cell Research</u>

As an aspiring computer engineer, I have always been fascinated by the intersection of technology and problem-solving. Throughout my studies, I learned theoretical concepts that sparked my curiosity, but I often wondered how they could be applied in practical, real-world situations. That curiosity drove me to seek out research opportunities where I could use my knowledge in a tangible way. When I received an email from Professor Winstead looking for students to work on improving the power efficiency of a LEGO brick used in robotics, I knew this was my chance to bridge the gap between theory and practice in hardware design. What followed was a challenging yet rewarding journey that not only enhanced my technical skills but also deepened my understanding of teamwork, problem-solving, and the engineering process.

I first learned about the research opportunity with Professor Winstead through an email he sent to the Department of Electrical and Computer Engineering Technology. He was seeking students interested in working on a project aimed at improving the power efficiency of a LEGO brick used in robotics. The moment I read the email, I knew this was the chance I had been looking for. As a student eager to apply my theoretical knowledge to real-world problems, this project seemed like the perfect fit. I wanted hands-on experience that would challenge me to think creatively and push me out of my comfort zone. My main motivation was to gain research experience and contribute to an innovative project that had the potential to impact robotics. The idea of enhancing a toy's power efficiency while learning about advanced technologies intrigued me, so I quickly reached out to Professor Winstead to express my interest.

Working with Professor Winstead and my research partner was critical to the success of the project. From the beginning, Professor Winstead was both supportive and challenging. He guided us when we needed direction but also encouraged us to explore solutions independently. His deep knowledge of electrical engineering helped us stay on course, and his enthusiasm for the project made me even more excited to dive into the work.

In addition to Professor Winstead's mentorship, I worked closely with my research partner. We developed a strong working relationship by constantly collaborating on solutions, testing ideas, and supporting each other through the tough moments. My partner brought a methodical approach, while I leaned into creative problem-solving, and together we were able to tackle obstacles more effectively. Our collaboration was key to making steady progress, and I learned a lot about teamwork throughout the process.

One of the biggest challenges we faced early on was selecting the right battery for the LEGO brick. The battery needed to be small enough to fit inside the brick but powerful enough to provide a long-lasting, rechargeable solution. We went through several rounds of testing different batteries, running into failures when they either didn't fit or couldn't hold enough charge. Eventually, we found a 1300mAh rechargeable battery that met both the size and capacity requirements. While this felt like a significant breakthrough, it was only the beginning.

Once we had the battery, we turned our attention to designing the circuitry. Here, space was the biggest constraint—we needed to design a compact circuit that could fit inside the tiny LEGO brick, all while including essential features like a battery level indicator and a sleep mode to conserve power. To achieve this, we selected the ATtiny85 microcontroller as the brain of the circuit. Its small size and low power consumption made it the perfect fit for our compact design. Using the ATtiny85 allowed us to control the various components and functions efficiently while keeping the power usage low.

To design the PCB, we used KiCad, an open-source PCB design software. It helped us create compact and efficient circuit boards that could fit inside the LEGO brick. Designing a functional circuit with limited space was a steep learning curve, especially since neither my partner nor I had much experience with PCB design. But through experimentation and multiple prototypes, we were able to develop a circuit that met the project's requirements.

In addition to PCB design, we also used MATLAB to simulate power usage and test how different circuit configurations would affect the battery's efficiency. MATLAB allowed us to visualize and predict how our circuit would perform under different conditions, helping us fine-tune our design before moving on to physical prototypes. This combination of software tools—KiCad for physical design and MATLAB for simulation; helped us overcome many of the technical limitations we faced.

The key to overcoming the challenges we faced was a combination of persistence and collaboration. When we struggled to find the right battery, we conducted extensive research, tested different options, and analyzed our failures. After finding the 1300mAh battery, we shifted focus to the more intricate problem of designing the circuitry. One of our problems was raising the voltage of the battery to 5V as we could only get a battery providing 3.7V. This was another problem for which we did not yet have the skills for. We explored so many options goings from the use of transistors, OP Amps to Chip that boosted the voltage. But none of those solutions seemed to be viable. We then turned to professor Winstead who advised us to build our own circuit to boost the voltage using what we call an "RLC" circuit. That gave me some hope to know that when I am stuck, I can refer to someone with more experience than me that can guide me through what's a good solution and what's not.

Designing a compact circuit required a methodical approach. We used KiCad to create several iterations of our PCB layout, testing each design for size, functionality, and efficiency. There were moments when things didn't work as planned; components didn't fit, connections failed, or the circuit didn't perform as expected. But by continually refining our designs and using

MATLAB to simulate different scenarios, we gradually found a solution. The ability to test and iterate using these tools allowed us to tackle problems early in the design process and reduce the number of issues we encountered when creating physical prototypes.

The trial-and-error process I experienced in this project taught me invaluable lessons about perseverance and problem-solving. Despite all the time and careful planning I invested, things didn't always go as expected—a reminder that setbacks are an inevitable part of any meaningful endeavor. However, I realized that as long as I didn't give up, I could eventually find a way forward. There were many moments when I felt stuck, times when I wanted to give up entirely because the problems seemed insurmountable. Yet, with Professor Winstead's encouragement and guidance, I found the strength to keep going. This project showed me that both life and challenging projects are rarely meant to be tackled alone; with the right people by your side, even the most difficult goals become achievable. This experience has left me with a deep appreciation for resilience and the importance of collaboration in overcoming obstacles.

One of the most rewarding aspects of the project was successfully designing a sleep mode for the LEGO brick. When not in use, the brick would enter a low-power state, conserving energy and extending battery life. We also created a battery level indicator that let users easily check how much power was left. These features made the LEGO brick more user-friendly and energy-efficient, aligning perfectly with the project's goals.

In the context of our power cell project, the ethical use of information was essential at every stage, from initial research to final testing. Working with battery and power efficiency data, we had to ensure that all measurements and results were not only accurate but also transparently reported, as these factors directly impact the safety and functionality of the LEGO brick in real-world applications. Any inaccuracy could lead to overestimations about battery life or power stability, which would ultimately mislead users and potentially compromise the brick's safety and reliability in robotics applications.

Furthermore, while designing the battery system, we carefully considered the environmental and sustainability aspects of our project. Power efficiency isn't only about improving functionality; it's also about reducing waste and conserving resources, which aligns with responsible engineering practices. By prioritizing these ethical considerations in our design, we aimed to create a system that not only performs well but does so sustainably and safely, reinforcing the trust that users place in our work. This approach has underscored the importance of ethical responsibility in every project I undertake, setting a standard for how I'll approach similar challenges in the future.

Looking back on this research project, I am struck by the depth of growth I’ve experienced as an engineer. Beyond technical skills like PCB design and power management, I learned the crucial step of translating theoretical knowledge into practical, real-world solutions. Gaining proficiency in KiCad for circuit design, MATLAB for simulations, and utilizing the ATtiny85 microcontroller to manage controls has expanded my technical toolkit. These skills allow me to break down engineering challenges systematically and creatively, equipping me to tackle complex projects with more confidence. This experience has not only helped me develop as a problem-solver but has also cemented my commitment to engineering as a field where constant learning and adaptability are essential.

The hands-on challenges I faced during this project have given me valuable preparation for future projects, including my current one this semester. I’ve come to understand that engineering is not solely about solving problems but about doing so efficiently and effectively within limitations such as size, time, or resources. Working within these constraints trained me to prioritize and refine my approach, ensuring that I’m always thinking critically about the best use of available resources. This learning has practical relevance; as I take on more projects, I can approach them with a strong foundation of persistence and adaptability, knowing I can refine my methods to meet even the most rigorous demands. I feel ready to bring this mindset to any engineering problem, knowing that iteration and persistence are powerful tools for success.

Moreover, the teamwork aspect of the project was invaluable. Collaborating closely with my research partner and learning from Professor Winstead highlighted the importance of communication, collective problem-solving, and the value of shared insights. Working together taught me how to approach engineering problems from multiple perspectives, blending different approaches to overcome challenges more effectively. These interpersonal skills are crucial in any technical field, where teamwork and collaboration often determine the success of a project. I now recognize that these soft skills—communication, trust, and collaboration—are as essential to my career as the technical skills I’ve gained, providing a well-rounded foundation for my professional growth.

One of the most impactful lessons I took away from this project is that failure is not only inevitable in engineering but also instrumental to learning. Each setback, whether due to a battery that didn’t fit or a circuit that didn’t perform as expected, pushed me to think more critically and creatively. I’ve learned to embrace failure as an opportunity for growth rather than a dead-end, recognizing that it often leads to more refined, thoughtful solutions. This perspective matters deeply to me as it aligns with my aspirations to innovate and push boundaries in my career. I now approach challenges with resilience, seeing each obstacle as a stepping stone toward greater insight and accomplishment in engineering.

I liked everything about this project but I do have one regret; We did not share our research in public because I thought that the research was too small or not innovative enough to be presented at the research symposium our professor proposed us to sign up for. It was due to the lack of confidence and honestly some shame of the time it took us to realize a simple project. In the future, I will not make that mistake again and no matter what my achievement is I will share it with the grand public.

Conclusion

The skills and lessons I gained from this project will be valuable in many ways, both in my career and personal life. Professionally, learning how to design a circuit board with KiCad, simulate power usage with MATLAB, and work with the ATtiny85 microcontroller has prepared me to handle complex engineering tasks. These skills mean I'll be better equipped to take on future projects, whether I'm creating new designs or fixing existing ones. I feel confident that I have the technical abilities and problem-solving approach to face challenges in my field.

The teamwork experience was just as important. Engineering is almost always a group effort, and working with Professor Winstead and my partner taught me how to communicate clearly, listen to others' ideas, and use our different strengths to improve our work. These teamwork skills will be key when I work with others on future projects, where successful collaboration can make a big difference.

Personally, I've become more resilient and adaptable through this experience. Facing setbacks and finding ways around them taught me that persistence is crucial and that every challenge has something to teach. This mindset is something I can apply to all areas of my life, helping me tackle problems without giving up. Moving forward, I'm excited to use what I've learned not only to reach my career goals but also to grow personally, using these lessons to keep improving and learning along the way.

This project has also engaged me professionally by immersing me in the practical realities of engineering, going beyond theoretical knowledge to confront real-world technical and collaborative challenges. Working on the power cell solution for the LEGO brick required me to apply professional-grade tools like KiCad for PCB design and MATLAB for circuit simulation, skills that are directly relevant in engineering industries. This hands-on experience has strengthened my technical foundation and allowed me to work within practical constraints like space, power limitations, and system efficiency—all critical elements in hardware design.