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Senior Project

5/2/2030

An Odyssey of Design

As I reflect on my senior project, I have come to realize that the project I set out to do was not the one I ended up doing, at least not entirely. I set out to do a project that I thought would be acceptable but that left out a key part of my interests as a designer and a person. I realized this when I started to write my paper, and was encouraged to explore this further and even include one of my personal projects that is more aligned with all of my interests as a part of my overall senior project journey. Doing this led to a deeper exploration of myself and ultimately gave me new knowledge about myself in relation to others and the world.

Why I chose the project

I chose this project because it seemed like the most acceptable of my project ideas, and would relate to my interests of 3D printing and design. I spend much of my time designing and making things, so it was something I felt I could actually get excited about; something that I knew was essential in order to have a successful project. It took me a while to decide on a project that I thought I would enjoy. I initially was very lost and really couldn't come up with something that I felt was acceptable and achievable, yet also big enough that it would last throughout the year. Building a compost tumbler was one idea I had. I imagined designing a frame that would hold a large rotation drum that would be automatically rotated by an electric motor. This motor would then be powered by solar panels and a battery. This project seemed complicated enough to be a long term project, but also seemed reasonable to build and refine to a finished state. For about the first month of school this was my project plan, but I never really felt very excited about it, never started on it, and kept exploring other possibilities. I realized that a couple years ago, a woman named Daphne had talked to me about possibly doing some design work for her. She owns a company in Sebastopol called Ochs Labs that produces medical devices. One of these devices is called a photonic stimulator which is a photonic stimulator is a low-level light therapy (LLLT) device that uses an array of near infrared LEDs to help heal wounds, and reduce pain, inflammation, and tissue damage. Low-level light therapy is still a fairly new technology developed in the late sixties, but studies have show that stimulation of the brain with near infrared light may be able to help treat brain disorders, diseases including Alzheimer’s and Parkinson’s, and psychiatric disorders including depression and anxiety, PTSD, autism, and addiction (Michael Hamblin, PHD). The current photonic stimulator that Ochs Labs sells was designed over 20 years ago and is very blocky and not very sleek or ergonomic (see works cited for product info).

(Image of the Photonic Stimulator)

Daphne was interested in having me help design a new and improved version of the photonic stimulator, something that sounded like a great opportunity to me. I checked in with her and asked if she would still be interested in having me do some design work for. She was completely on board and very excited. This project seemed like it had great potential for unique and challenging experiences and after talking to Daphne, I decided that this was going to be my project. Going in my hope was to get some experience doing work for someone other than myself, experience working in an office, and an opportunity to use my design skills and problem solving skills to work on a real world project with the potential to have a positive impact on others. I got to experience working on an engineering project like I had hoped, but I also got to experience really fun and effective collaboration, something that has shown me some new things about my own design process. I had initially planned to work on the project alone, but a new employee at Ochs Labs named Oran ended up working on the project with me. He was the perfect project partener to have in this scenario. He knows a lot more about electronics, programming, and circuit design that I do, and he was able to completely redo the electronic system of the photonic stimulator, while I did the case design. Together we were able to create some very nice prototypes, something that would have been much harder to do if I had worked alone.

What hardware I started with

The photonic stimulator uses an LED array with an 8x8 grid of miniature LEDs that produce infrared light (see works cited for data sheet).

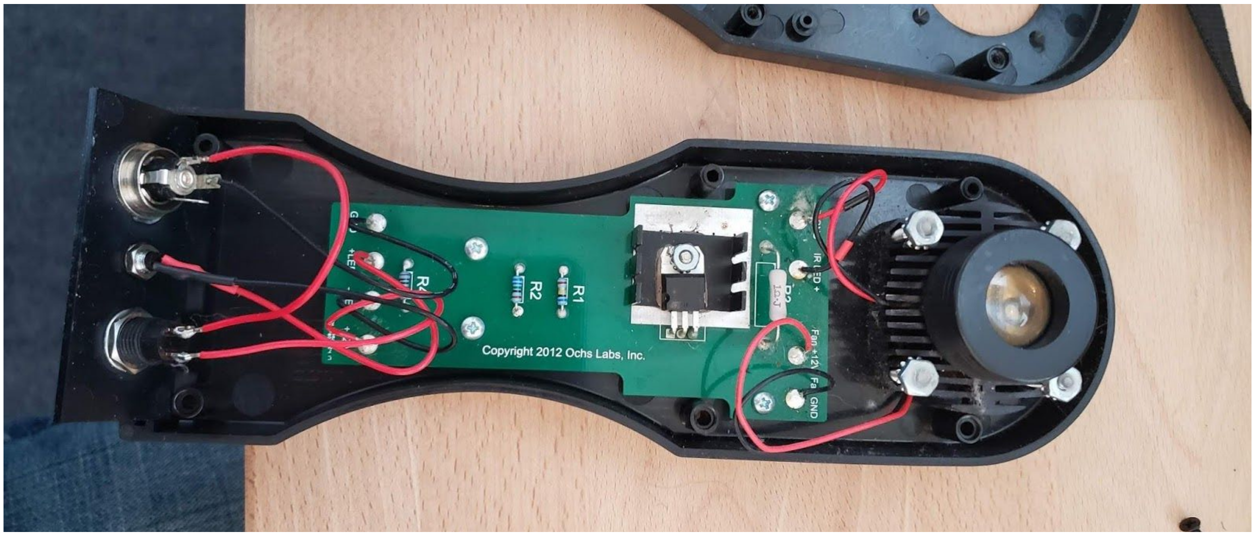
This array is very small but produces a great deal of heat, so it must be paired with a large aluminum heatsink to help dissipate the heat. Above the array is a lense that helps to dissipate the light from the array, allowing it to cover a wider area, similar to how a flashlight creates a wide beam with a concave lense. Below the heatsink is a 40mm cooling that runs constantly when the LED array is turned on, in order to help cool the heatsink and dissipate heat from the array even more. This is the main hardware that makes the device work as desired, and we did not change any of it. We did consider making some changes and may do so in the future, but at the moment all of the components and their layout remain the same.

In order to power the LED and cooling fan, the device needs a power source. This comes in the form of a 110v ac to 12v dc power supply similar to the ones used to power laptops. This will power the cooling fan with no issues, but is too much voltage for the LED array which is only rated for 8v. This is why the device needs a circuit board. On this circuit board is a voltage regulator that steps down the 12v from the power supply to 8v for the LED array. As mentioned before, the cooling fan still uses the full 12v from the power supply. This discrepancy makes the whole design a bit more complicated and presents a few issues which I will discuss in further detail later on. In order to turn the LED array on and off, there is a push button that latches when you press once, and then unlatches when you press it again. This allows it to keep the device on without the use having to hold the button down the whole time. One could say the button holds itself down in a sense. We never ended up changing the original button, but only because we could not find a suitable replacement that would fit our needs. The button used in the production photonic stimulator is not suitable for our design, but worked as a placeholder during prototyping. The final component that will likely also get changed is the plug that connects the power supply to the device itself. We didn't end up changing it for the same reasons as the button, but this part will also likely get replaced with a different style of plug in the future.

These are all of the main hardware components that make the photonic stimulator work. In order to get components for our project, we cannibalized a couple photonic stimulators from the storage room at the office. We mostly used the components from the original device, except for the circuit board which was useless to us. As for the case, we ended up using it for reference of some dimensions and specs, but of course did not actually use it for making a prototype. After all, the main goal of the project was to redesign this part.

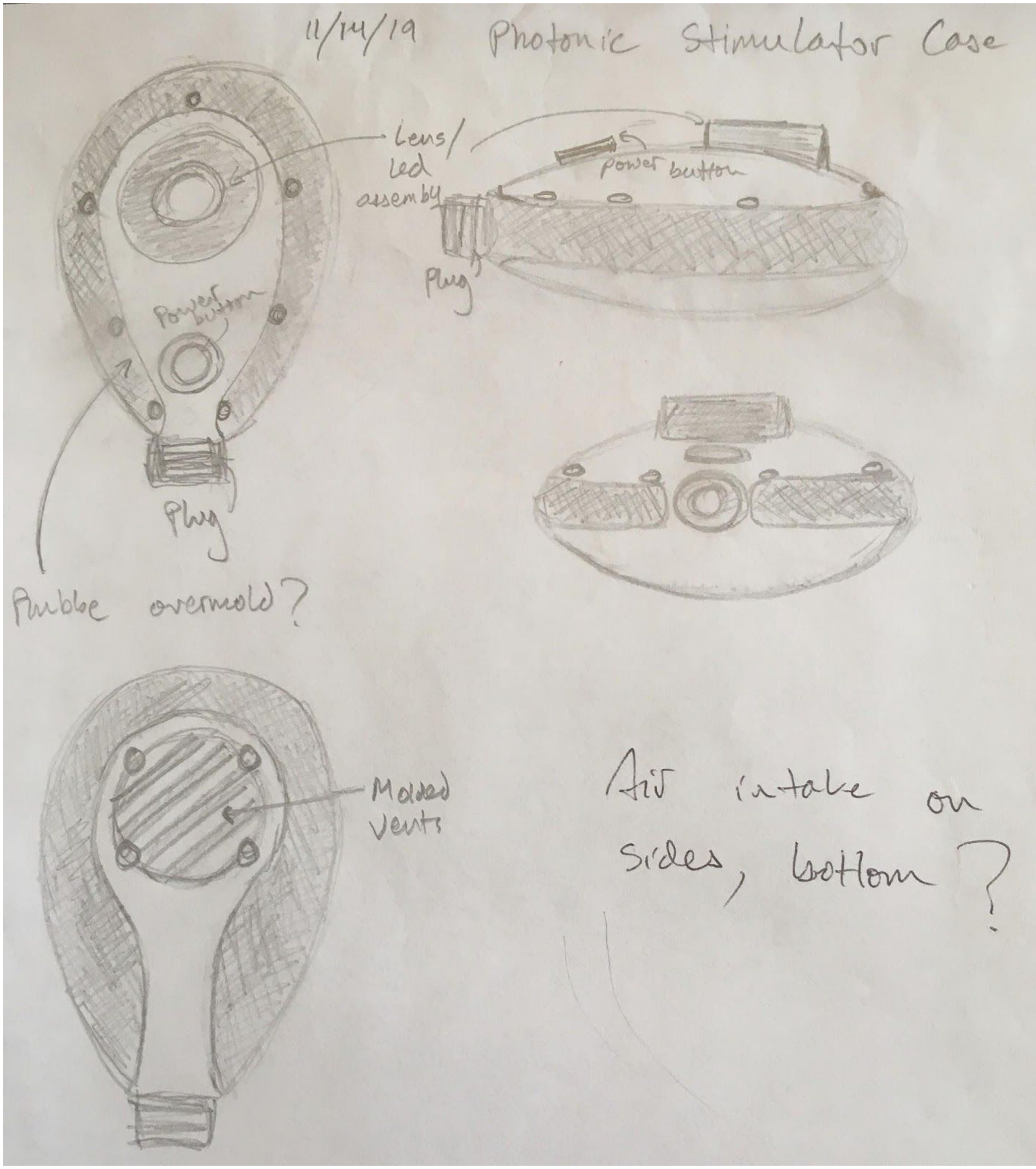
Process/What I did

On the first day of work, Oran and I started by discussing some of our ideas, and reviewing some of the project goals that we had discussed with Daphne the week before. The main requirements that we needed to consider were improved ergonomics, improved aesthetics, and improved usability. The original photonic stimulator case was very large and blocky. It also had a giant circuit board inside it that was unnecessarily large and would not be practical or even possible to use in our newer design. As seen in the picture, the green circuit board holds only a few components and is much bigger than it needs to be.



(Disassembled photonic stimulator.)

The very first design idea I had after talking to Daphne for the first time was a much more compact design that would fit in the palm of the user's hand, a bit like a large bar of soap.

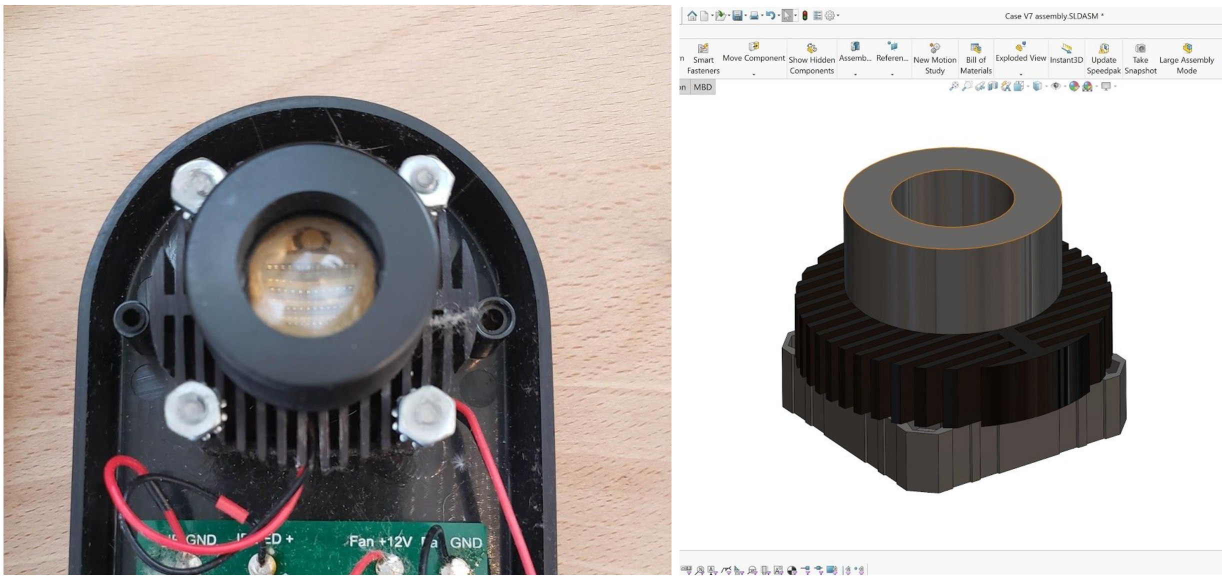


(Early sketches of initial design idea.)

In order to make a more compact design like this we had to use a new layout for the electronics because the old circuit board was so large. Because of this limitation, Oran decided to completely redesign the circuit board. The actual circuit stayed the same as the original but the new board had a much smaller footprint, making it possible to fit in much more compact designs. Later that day Oran had finished the design and sent it to a company in China who would make it for us. After we made the decision to make a more compact circuit board, we discussed making some prototypes of the case. I showed Oran the design I had come up with before, and he suggested a couple new approaches we could take as well. We eventually settled on trying the compact version that I had come up with as well as a version of Oran's design that roughly matched the dimensions of the original photonic stimulator case, but had a much thinner handle portion that is easier to hold.

This process of brainstorming the design approach to take was always very collaborative. First Oran and I would both discuss the ideas we had to try to get as many options on the table, then we would refine which ideas we wanted to bring together to create a cohesive design. Unlike most of the other projects that I do by myself, this project used not only my ideas but also Oran's ideas to collectively create a design. This ultimately made the process of brainstorming a design more efficient for a few reasons. When we had a problem, it was easier to find a solution because we could both try to find solutions separately, and then also build solutions from the ideas of the other person. Brainstorming also took less time because we could help each other see the pros and cons in our ideas that are sometimes not as easy to see when working alone. By having another person evaluate your ideas, they can help quickly determine what will work well and what won't, ultimately narrowing down the ideas to only ones that seem like they can be realistically implemented.

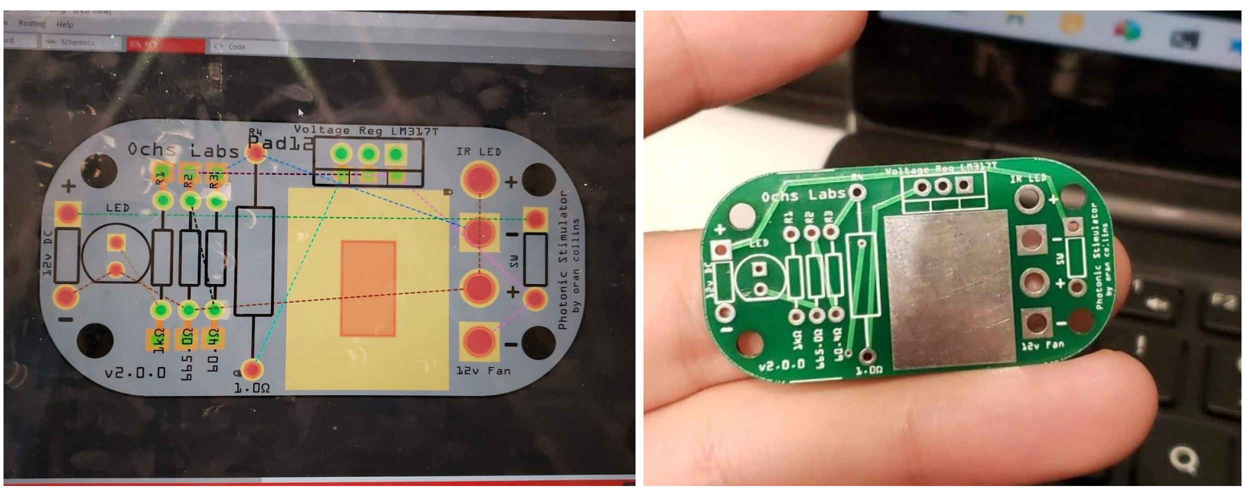
I got to work designing the two different versions previously described. The design process was fairly free, but I did have to work with some constraints. I had to design around the original LED array and heatsink and fan that sits behind it, and also leave space for a circuit board. These constraints limited how small I could make the new case design, but this didn't end up being an issue.



(Left: Top view of LED array and heatsink in the original case. Right: CAD model of fan (bottom), LED array heat sink (middle) and LED array cap (top) used for reference when designing.)

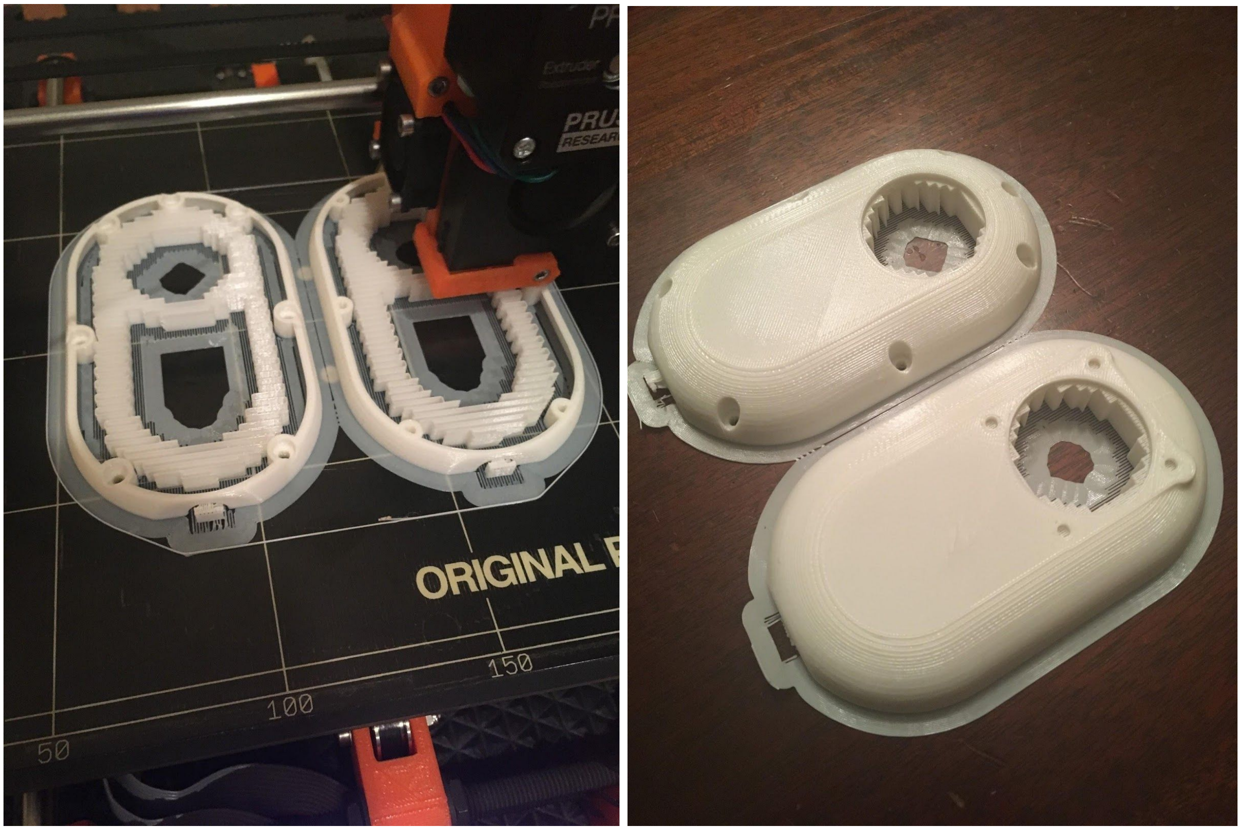
I designed the case with two halves that were held together with screws that were located around the outside edge. The initial designs were very simplistic and only had the goal of getting a basic shape made. I chose to leave out certain features like holes for the power button, power plug, and the power indicator LED because the shape of the new design would determine their location and changes in the case could require a full rework of these features. In this way I focused on bringing the basic ideas of the case to life, without worrying about the details. This makes the design process significantly easier because I can prioritize making the most important parts of the design work, and then create the detailed parts of the design around the initial form. Otherwise issues can arise where less important aspects of the design might negatively affect more important parts of they are added to early.

After my first day of really working on the project, I had CAD models of both designs mostly complete and Oran had ordered the first prototype of the new circuit board from China. Nowadays getting small batches of circuit boards made is very cheap and a batch of 5 boards only cost us about $10.

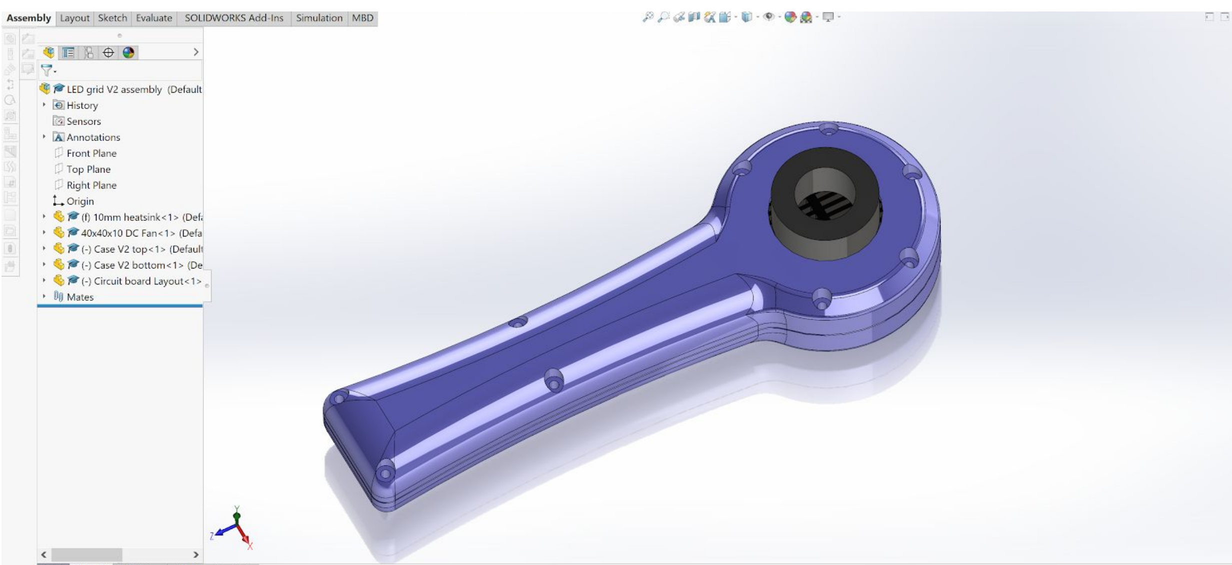


(Left: Circuit board design on Oran’s computer. Right: Actual Circuit board custom made in China.)

After I had finished the new case designs at home, I printed them on my 3D printer (see works cited for product info).

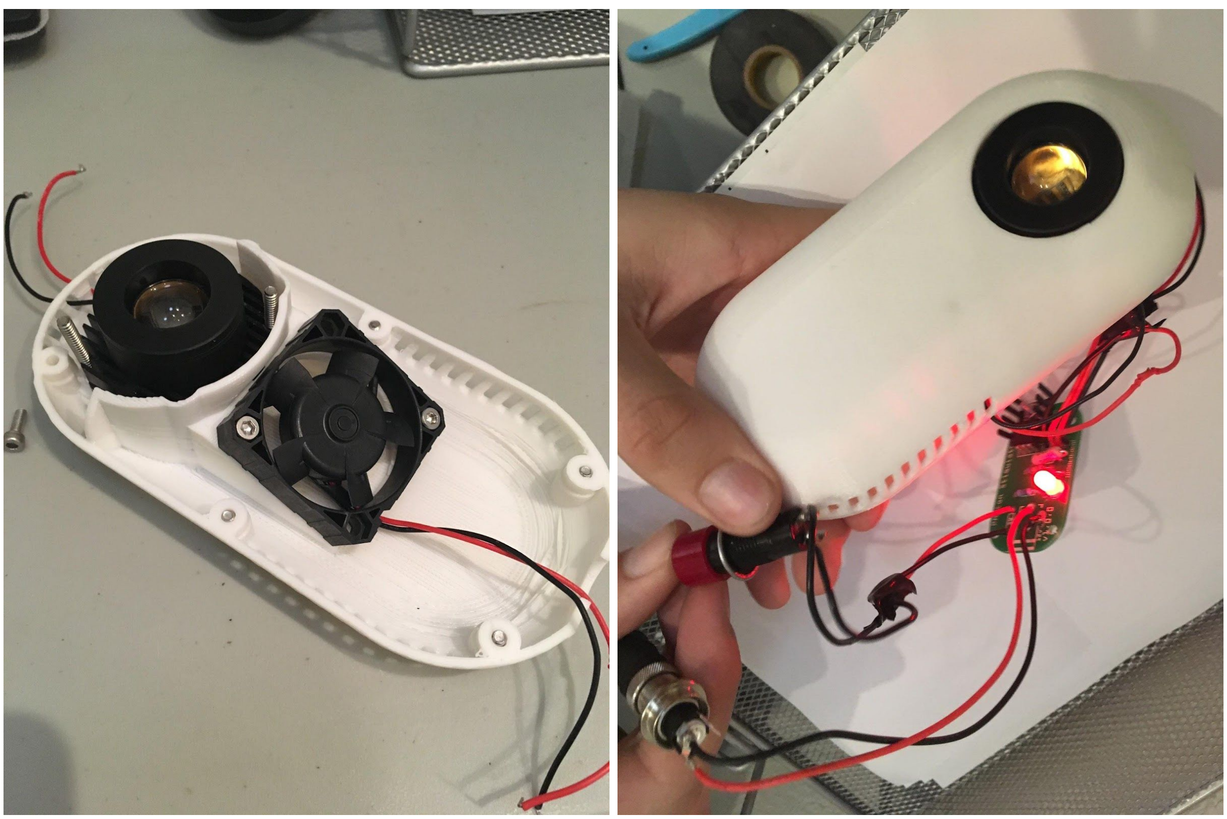


(Left: First case design being printed. Most of the material inside is support material that is removed later. Right: Finished print after being removed from the printer. Support material is still attached.)



(Cad model of second design that Oran suggested. Purple parts are printed, black parts are reference parts that represent the LED array and heatsink.)

Using these first 3D printed prototypes, Oran and I were able to start getting a sense of what designs we wanted to move forward with. The first prototypes were far from perfect, but they gave us an idea of how things would start to fit together. During the rest of my apprenticeship week, we continued to revise these first two designs. I played around with relocating the cooling fan for the LED array in order to make a more compact palm sized version, and tried adding side vents to help with air intake for the fan. We ended up wiring up a second prototype of the small palm sized version but ended up taking a different path towards a more polished prototype.



(Left: Early prototype with relocated cooling fan and venting. Right: Prototype fully wire up)

Oran wanted to explore making our other skinny handled prototypes have a much longer handle, allowing the user to have greater reach and mobility when using the device on their back or shoulders. I edited my design of his original idea and printed a prototype. It turned out to be very comfortable and seemed to be a better design to continue developing into a fully functional prototype, so we decided to ditch the compact palm design in favor of the long handled one. There has still been interest expressed in having a more compact design like the one I first made, especially for travel, so maybe I will explore that idea again in the future.

After we had settled on a design style to pursue, Oran and I started to discuss making adjustments, and adding the more detailed features. One of the features we decided to add is vent slits all around the portion of the case where the cooling fan, LED array, and LED array heat sink sit. On the current design that Ochs Labs produces, there is an intake on the backside of the device that provides the cooling fan for the LED array with a steady stream of air. Or at least does until it is covered up. When people use a photonic stimulator on their back, they often like to lean back on a couch or pillow so they don't have to hold it in place for half an hour. This covers up the intake for the cooling fan, and can cause the device to overheat. The LED array that the photonic stimulator uses gets hot extremely fast and if the fan cannot get air to cool it can overheat, something we want to avoid. In an attempt to solve this issue, we added venting all around the area where the fan is located, in addition to vents directly below it like the production version has. By doing this we hope to make it almost impossible to cover up all of the vents, which we hope will greatly reduce the chances of the LED array overheating. We have yet to test how well this works, but so far the solution seems promising.

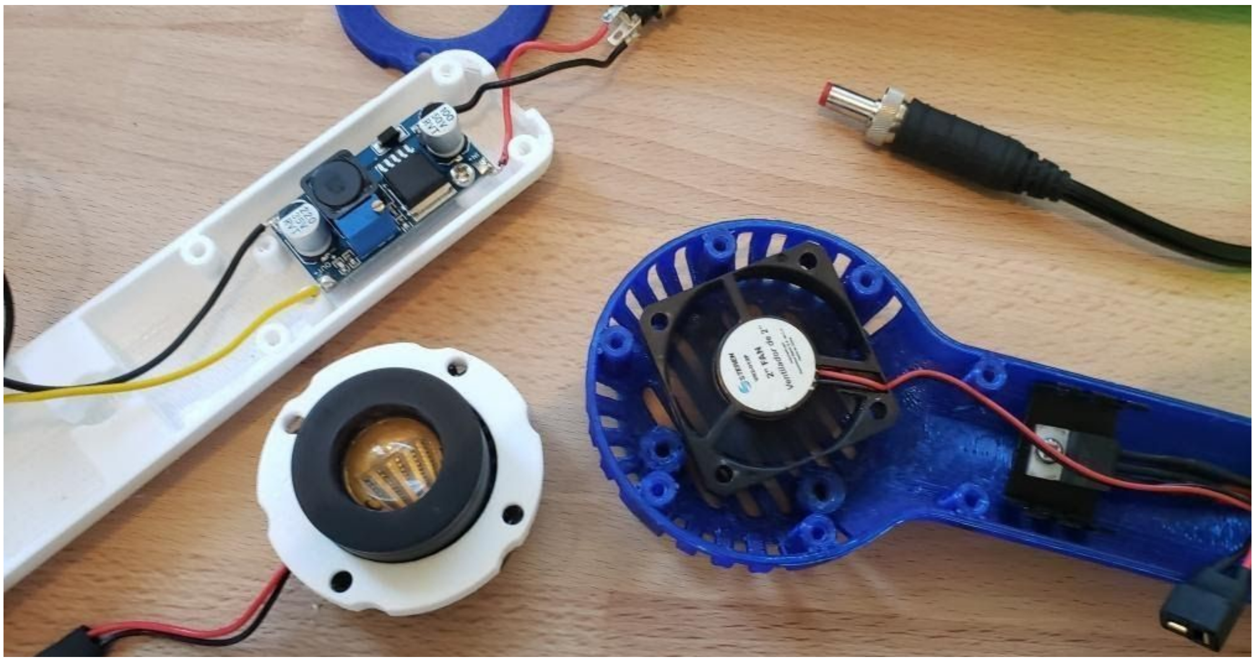
One of the initial issues we encountered was that we could not get the LED array to turn on when we connected it to the new board that Oran had made. At first we suspected that something was wrong with the board and tried connecting the LED array to the board from one of the photonic stimulators that we canabilized for parts. To our surprise, the LED array didn't work with the original board either. This was very odd and the only conclusion we could come up with was that we had somehow managed to fry the LED array with the new board. However, there was no no visible damage to the LEDs, which seemed even more odd. Oran troubleshooted this issue during his spare time for a week or two, and eventually tried hooking the LED array up to a power supply and incrementally increased the voltage. He said that the LED array eventually lit up, which meant that it was in fact not fried. Unfortunately a couple of the LEDs in the array fried shortly because they were being supplied with too much voltage. This confirmed that Oran's board had not fried the LEDs. However, it still did not explain why the LED array would not turn on when connected to his new board, or the original board for that matter. Oran reviewed his board design again and eventually found that the pin layout was wrong for the voltage regulator that drops the 12v from the power supply to 8v for the LED array. This meant that the LED array was not getting any voltage, and explained why it would not turn on. Oran fixed the issue by attaching the component to the board with some wires, which allowed him to reorder the pins in the correct layout. The LED finally lit up, and the board worked as expected. This was a super exciting breakthrough. After being stumped for multiple weeks, it was very nice to finally be able to figure out the issue. I have to give Oran the credit for finding the problem here, as I contributed very little to that part of the project. It was still very satisfying to know that the device we had been struggling to get working would actually work now. A couple days later, we got together at the office and assembled our very first fully functional prototype. This was incredibly rewarding to finally have gotten to a place where we really had something to show for our hard work. At this point we had reached our goal of creating a fully functional prototype.

(Left: First fully functional prototype next to original case. Right: Prototype with case removed to showcase internal components.)

Another issue we encountered was that the voltage regulator that drops the voltage for the LED array gets incredibly hot after about 15 minutes of usage. This is an issue with current design that is in production and although there is no functional issue, it does make the case very hot around the area where the voltage regulator is located. On the current production model this area is generally not directly touched by the user during use, but in our design it is. Since the electronics have to be placed in the handle, the voltage regulator is going to be in a place that the user might hold no matter where we put it. This means that a part of the handle will always get very hot, and although it is not too hot to touch, it is hot enough to create discomfort. We still don't have a permanent solution to this issue, but we considered a few different things and tried to implement one solution. One solution would be to get an LED array that is rated for 12v instead of 8v, but that would require the part to be custom manufactured which may not even be a possibility. Another much simpler solution is to get a different power supply that only outputs 8v. This would be simpler and easy to implement but would still require a big change down the road in production. This might be the best solution down the road, but we still have many other parts of the design to finalize before we will likely explore it too much further. After we had made our first fully functional prototype (shown above) Oran came up with a third solution that we tried: getting rid of the voltage regulator we were using and replacing it with a buck converter circuit. A buck converter circuit serves the same purpose of dropping the input voltage down like the voltage regulator chip we used, but it does it through a different process. Using an inductor coil, some transistors, and a capacitor, the buck converter drops the voltage more efficiently than the voltage regulator we used (Buck Converter: Basics, Working, Design and Operation).

We hoped that the buck converter circuit could serve the same purpose as the voltage regulator without producing as much heat.

Oran bought a buck converter and we tested it out in a second prototype. After completing our first one, we wanted to make a few more and give them to people around the office to test. When making the second one, we decided to test out the buck converter.



(First and second prototypes open buck converter shown in handle of white case)

We connected the buck converter to the LED array and let it run for a few minutes. Unfortunately the buck converter got very hot just like the voltage regulator, so this didn't solve our problem. We decided to build the second prototype with the same board as the first, and didn't make any changes. Since the device is still functional despite the voltage regulator getting very hot, fixing the issue is not essential, especially at this stage. I would like to find a way to fix it down the road to improve user experience, but that may not happen anytime soon.

Current State of the Project

After we finished making a couple of fully functional prototypes, Oran gave them to people around the office to use and test. The plan was to have people test them for about a month and then give us feedback on what features they liked and what they would like to see changed. I mostly left this up to Oran since he works in the office as an actual employee, and he said so far people seem to like the design. However, the project has been put on hold because of the global pandemic we are currently in the midst of and we have not talked to anyone in depth about things they think could be improved. We know that we also need to make some changes regardless of the feedback we get. These are finding a better power button, finding a new style of plug for the connection between the device and the external power supply, and most likely changing the circuit board to accommodate these changes. At this point we have not found a suitable button, and we are unsure what connector we will end up using. This decision is really not up to us so we are still a bit stuck. We are in a position where a few decisions need to be made before we continue to develop a project, and currently those decisions have been put on hold. However, getting feedback and deciding what button and plug to use are the next steps we need to take.

Holding Myself Back

All throughout high school I have one of my most enjoyable hobbies has been tinkering with Nerf blasters. Most of my engineering projects are linked to Nerf in some way, some more directly than others. Despite this being the thing that I am most excited about doing in my free time, I feel that I have had to not share this part of myself around school. When I was in the lower school, I got the sense that some of my teachers did not appreciate my love of Nerf blasters. A friend and I were once told that school was not an appropriate place to talk about Nerf and from that I formed a belief that the Waldorf community as a whole was not supportive of the thing I loved. How accurate this is I am unsure, and I do not know if I simply felt a judgement that was really not there. I understand that some people have their reservations about Nerf blasters because they are related to guns, a very controversial topic today. To me Nerf is a source of fun, connection with friends, and an opportunity for great projects. Going into high school I imagined that teachers would not judge me as much for my interests, but I still carried that feeling of judgement with me, and still hid that part of myself most of the time.

What my project ultimately showed me was that I still feel like I can’t do what I am most passionate about because I have fear of others’ judgement. Finding a project that I was even remotely interested in was so hard for me because all I really wanted to do was work on my Nerf projects. I didn’t realize it at the time, but I had to try to find something that I thought was acceptable to do as a project because I felt that what I really enjoy wouldn’t be approved. I didn’t even bother trying to get a Nerf related project approved because I could never imagine standing up on stage presenting about something even remotely related to guns. I just couldn’t imagine it being received well.

Though not well known, there is in fact a worldwide community of people centered around the Nerf. Including myself Nerf is more than a toy, and is actually a hobby. I and many others love to tinker with Nerf blasters to make them shoot harder, faster, and with more precision. With the rise of consumer 3D printing, many people in the Nerf community have also become interested in 3D printing and fully custom 3D printed Nerf blasters have become very popular. Along with building and modifying blasters I also go to many Nerf games in the Bay Area, usually with anywhere between 30 to 100 people ranging from young kids to adults often including their parents and even grandparents. Sometimes my dad plays when he is not busy working and he has a great time. These games are truly fun for the whole family and are a place to actually use the blasters we have created and modified in battles against each other, something that is incredibly fun. By going to these games, I have formed a whole network of friends who are interested in the same things I am. There are even competitive games with stricter rules and designated teams. In October there is an annual weekend long event in San Jose that hundreds of people from all over the US and even the world attend. At this event I played with a team of friends in a competitive tournament and won second place. This brought a whole new aspect of camaraderie and team building for me.

(Me and my team after the competitive tournament.)

I keep in contact with my friends and the wider community through apps like Discord (basically a giant group chat), Facebook, and Reddit. For me Nerf is not only a source of fun as an individual, but also a source of connection with many great friends, and a great source of projects that incorporate many different types of engineering. I have spent thousands of hours working on hundreds of nerf projects over the past few years that include aspects of mechanical engineering, electrical engineering, computer programming, and additive manufacturing (fancy term for 3D printing). All of the Nerf projects I work on incorporate some or all of these design elements, especially mechanical engineering and 3D printing. A few years ago I became very interested in using air as a power source for custom homemade Nerf blasters. Using air as a power source provides a variety of advantages: high power, high rate of fire, and good accuracy. Usually it is hard to get all of these features in one package with more common spring powered designs where a spring piston must be charged by the user before every shot. A pneumatic system essentially does this for you, making pneumatic blasters a very high tech option. Being a person who always looks for ways to make the best end product possible, my interests naturally gravitated towards pneumatic blaster designs, commonly referred to as high pressure air (HPA) blasters. Unlike conventional Nerf blasters, HPA blasters are connected to an external air source like a high pressure air tank (HPA tank) that can store a great deal of compressed air at thousands of psi that is then regulated down to a pressure that is suitable for use in Nerf blasters (about 20-100 psi).

Over the past few years I have made two completely custom made HPA blasters from scratch using 3D printed parts of my own design, off the shelf pneumatic components, and even custom machined parts. Last summer I embarked on a long journey of developing my most recent HPA blaster that uses a custom machined piston to actuate and fire the blaster. What made this project special is that nobody before me had ever used this piston design in a Nerf blaster before me, meaning that I was exploring a completely new technology in a way. Not only that but I hoped to build a blaster that fired faster than any other HPA blaster of this style ever made, making it not only sport unexplored technology, but also use that technology to make it be one of the best performing HPA blasters I have seen built to date. This excited me because it was an opportunity to make something incredibly unique and special, something that is very hard to do in today's world where it is very hard to be original. I am not saying that my idea was entirely original, but it was still very unique.

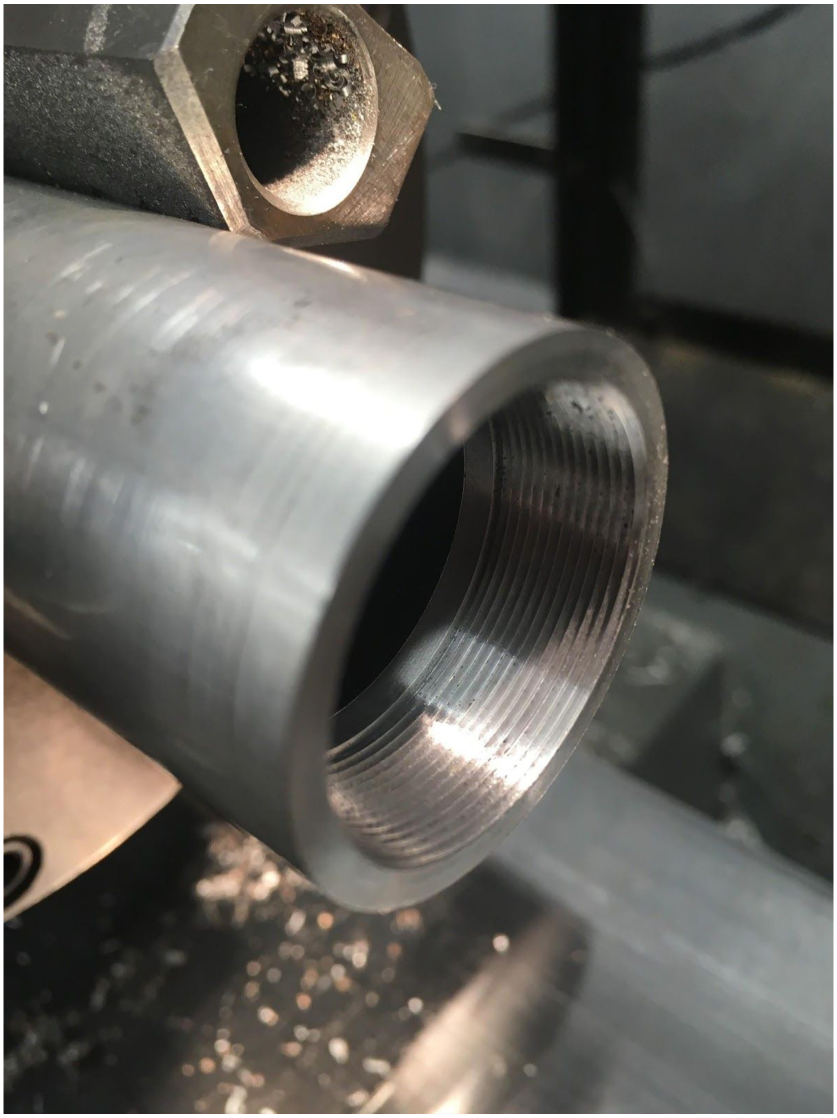
Despite my extreme excitement about the project, it took me a very long time to complete. The most challenging part was making the custom piston that makes the blaster function. I went to a machine shop used a lathe to machine it out of aluminum, which required me to learn how to do quite a few new things I had never done.

(Me working on the lathe I used to machine the custom piston for my hpa blaster)

I had taken a few machine shop classes at 180 Studios in Santa Rosa which gave me the basic knowledge of how to operate a lathe and not hurt myself in the process, but there was still a great deal I didn't know. Machining the custom piston for my HPA blaster required me to take plain aluminum rods and machine them into complex parts. I had to learn how to do many different types of cuts including how to cut threads into the parts in order for them to screw together like, and how to cut grooves for rubber o-rings that create airtight seals.


(Right: The beginnings of the main rod of the custom piston. This was cut from a solid rod. Some of the rod is completely untouched at this stage and can be identified by its matte finish. Left: The mostly finished part with o rings installed. This part reciprocates every time a shot is fired.)

In the image below you can see threads that I cut on the inside of the aluminum tube of the



piston. This allows me to screw a threaded end cap into it. Even before adding threads to the parts, they were fairly complicated to machine for someone with very little experience, and the whole process of creating the piston took many hours. I also did not get many opportunities to go to the machine shop so it took me all summer and then a few months into the school year to complete the machining. Looking back I realize just how long this took and how much less time it would take me now after learning how. I think I could comfortably machine a whole new piston in a weekend if I could spend all day at the shop. However, this was not the reality when I was working on the first iteration. Towards the end of summer I had enough of the machining done that with some 3D printed parts, tape, and zipties I was able to make a testbench setup that would allow me to actually make sure the design would work.

(Test bench setup used to test my custom piston.)

Until then I still had not confirmed whether or not the system would even work as expected, but I quickly realized that I worked even better than I had hoped. I used a solenoid to control airflow to a custom piston and used an arduino to control the solenoid. In order to get the mechanism to work I had to pulse the solenoid on and off to create a burst of air to cycle the piston and fire a shot. I was able to get the system to fire at a very high rate of almost 20 darts per second, about twice as fast as any other HPA blaster I had ever seen built, which meant that I had accomplished my goal of making the fastest firing HPA blaster of its kind. This was in September, right before school started. During the first few months of school, I made very little progress on the project, until Christmas break when I worked on it non stop for a week straight. During that time I did almost all of the design work of the actual blaster shell that would house my custom piston. I 3D printed the whole shell and used machine screws to hold all of the components in place. Despite being almost entirely 3D printed, the blaster is quite strong because of the nature of the design.

Even in the past few days I have found ways to improve this blaster, and will likely continue tinkering with it for a long time. The nature of the project allows me to continually be improving things without worrying about meeting deadlines, or goals for a product. I can just keep testing new things to try to improve upon the design and hopefully when I am in college with frequent access to machine shops, I will be able to machine new and improved versions of my custom piston and make a whole new version of the blaster.

How the project relates to my life

My entire life is dominated by design projects. At any given time I have about 20 different projects going, all at different stages of completion, and on some occasions I actually finish one of them. The projects vary in size and complexity, but usually involve 3D design, 3D printing, electronics, and sometimes machining. Many of the core aspects of these projects can be found in the work I did at Ochs Labs for my senior project. 3D design and 3D printing are the most prevalent in the things I do, and that is consistent in my senior project. Until I started to work on my senior project, I had never done a long term project with a deadline. Since it was supposed to be a main part of the work I did during my senior year, I intended to prioritize it over my other projects and focus more of my time on it. This was also new to me because I usually prioritized projects based on interest and development of ideas. When I get stuck at a certain point in a project, or lose interest due to spending too much concentrated time on it, I usually move on to something else and may not revisit the other project for months. Doing this for my senior project seemed like it was not an option because it had a deadline and was meant to be a significant amount of work. Among all of my various projects, I always have one project that I work on more consistently and spend more of my time on. Usually my mind is occupied by thoughts about the development of the project and even when I get burned out, I never take a break for more than a couple weeks at most. I felt that in order to have a successful senior project I would need to treat my senior project as my main project that I would work on almost continuously.

Despite my intentions to focus most of my time on my senior project I could never only focus on it, and it never really became my "main" project. Thinking about my main project is like my default thought setting, and I never found this to be the case with my senior project. There were times I would think about it for a while, developing my ideas, but in the end I would always default back to thinking about another on my main personal project. After doing some intensive work on my senior project, I found that I began to feel less excited about it and would have to force myself to work on it. I have felt this feeling before when I get burned out working on a project for someone else, but make myself finish it anyway because I know I will get paid.

Usually I would just work on another project for a while, but I told myself I needed to keep working on it because I "needed" to. Over Christmas break though, I spent almost no time working on my senior project and instead spent much of my time working on the project that my mind would default thoughts to. This project was the aforementioned HPA blaster. I found that I would work for whole days on it and never need a break, because there was this excitement about working on it that I simply could not resist. I could stay up till one or two in the morning working on it, and still get up at eight the next day to continue the process. I worked for a whole week straight on almost no sleep until my body could not handle it anymore and my hands shook as I worked. At this point I realized I needed to take a mental break from the project, as well as provide my body with some much needed rest even though a part of me didn't want to. Though there were times where I worked on my senior project intensely, I never got even close to working till I was so deprived of sleep that I could barely function. Working for someone else with someone else was a wonderful experience, but I feel that the project was less personal and more separated from me. I think this is why it never really became my "main" project, never was the default project that occupied my thoughts, and never made me forgo countless hours of sleep. There was just something about a project that was all my own, created from my own idea, designed and built from the ground up by me, and ultimately brought into existence through my tireless work. It felt like a child to me in a way because it was a pure and wholesome manifestation of my creativity. Since I had full control over the goals as well as the process, it gave me an endless number of solutions to every problem, and an endless number of thoughts which occupy my mind with. There were no enforced deadlines, no constraints imposed by anyone other than myself, and ultimately no mental barriers because of this. I felt completely free, independant, and unhindered by anything except my ever cumbersome need for sleep.

When I look back on what I did for my senior project, I can't help but feel that I really didn't put in as much time as I could have, and I certainly didn't commit all of my free time to working on it. Although I really enjoyed the work that I did, I realize that I wasn't as passionate about it as I am about some of the other things I do. On weekends I didn't wake up excited to work on my senior project, not because I didn't enjoy the work, but because I wasn't driven by the prospect of seeing it develop. I realize that it felt more like school work that I needed to set aside time for, and not an ongoing project I would constantly think about. It never really became my "main project" that I would occupy most of my free time with, but instead was one of those projects that I would work on when I needed a break from my "main project." At any given time I have about 20 different projects that I am working on, some more than others, and usually there is one that I get most excited about and focus on for a while. Since the summer of 2019, this main project has been my HPA blaster project. This project was the one that was constantly on my mind, the one that I woke up excited to work on, and the one that I was really passionate about. I never felt that I could prioritize my senior project over this, it took my mind by storm no matter what.

Aspects of Working as a Team vs Working Alone

From my experience of working with Oran I learned how to effectively collaborate with another person on a design project, something that I had never really had the opportunity to do. I learned how to convey my ideas more effectively, how to use another person's ideas in conjunction with my own to create a better end result, and how to see the other person's point of view even if their ideas may clash with yours. Sometimes Oran and I had very different approaches and ideas, and so we had to present the reasons why we thought our idea would work, and then decide which direction to take. This happened very early on when I was interested in making a prototype that was as small as possible, and Oran was more interested in making one that had a long handle that would allow the user more reach. We both discussed why we liked our ideas, and we ended up settling on Oran's approach. I liked my approach because I felt it would be easier to use because of its compact size. It thought it would be less cumbersome to leave resting on a part of the body, less cumbersome to handle, and easier to transport. Oran knew that having a long handle would allow the user to put the device on harder to reach places like the back, something that people often do to help relieve back pain and inflammation. Having a long handle also gave us more room for all of the electronics which is very helpful in early prototypes. I ultimately decided that Oran's idea would be a better first step because it would give us more flexibility with the electronics as well as giving users more reach, something that seemed worth sacrificing compactness and portability for.

I think working with Oran was a very good learning experience for me as someone who has always worked alone. I really enjoyed the social aspect, and have realized how much it can help to have another person to develop ideas with. I still also find that working alone has its own appeal because I enjoy struggling with problems and coming up with a solution on my own. There is a rewarding feeling that comes from figuring out problems without anyone's help, and I think there is also great value in learning through this process. When working alone I also get more freedom to be creative because no matter which of my ideas I end up using, they are still mine. This makes the project more free and is great when I have a specific vision of what I want the project to be like my HPA blaster. When working with another person, finding solutions to problems often happens faster, and is great for situations where I feel less attached to what the end result will be. When working on the photonic stimulator the end result was undetermined and had to be created through the design process, so working with Oran was very helpful.

Final Reflections

My senior project started out as a design project and although that was a big part of it, it ultimately became an exploration of my inner self. It showed me how I approach projects, taught me how to work with others, and also reinforced what I am most interested in. It also made me realize that there are parts of me that I have not given enough exposure for fear of judgement. This ultimately led me to choose a project that I thought was acceptable, and not one that really let me show who I am and what inspires me most. What I have seen is that much of the judgment I have feared is really non existent and that I don't need to hide parts of myself in order to feel accepted. I have been told this before but have always had doubts regardless because of some past experiences. But those experiences happened many years ago, and throughout my years of high school I have only felt love and support from the Summerfield community for who I am. Going into the future, I want to be less guarded about who I am and the things that I love, even if some people do not approve of them. I really love what I do and how it has shaped me as a person and I recognize that despite some misguided beliefs I have actually encountered very little judgement for my interest in Nerf. Even if someone does not appreciate it the same way I do it does not mean they will not appreciate me for who I am as a person. Finally this project has shown me what a damn good engineer I am becoming. I don't usually like to brag but I can't deny giving myself credit for that. Getting to work for a company on an actual product really showed me just what I am capable of, and what possibilities the future holds. I am very excited to study engineering in college and hope that my education will allow me to work on projects that can help make a difference in the world. I know that I will always feel a connection to my love of design and engineering, and that it will always be a part of who I am. I want the world to see this part of me, because at the end of the day, I want to have the experience of feeling whole.

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