# S.P.A.R.K.


STEM. Products. Advancing. Real. Knowledge.

## Design Portfolio By: Will Volovich

Design Studio 2023-2024

# Topic Breakdown

*Different aspects of this design portfolio. Each aid in the entire design process.*

# Problem Statement

The past couple of years I have explored the world of STEM through a vast range of *personal* projects. However, I have done little to impact the community, and above all, positively influence aspiring engineers. My goal is to create a teaching tool that helps young engineers grasp how seemingly complex parts work and behave. I want to achieve this understanding by creating larger scale 3D printed models of these components that actually function, and can be easily deconstructed to tinker with. If I have learned anything from my journey in STEM so far, it's that it all starts with taking things apart.

My project is geared towards STEM/general science related courses taught at the 6th, 7th, and 8th grade level. This is why I am choosing to email two middle school STEM teachers to be my design mentors. While this is the ideal target demographic, anyone can learn from these tools.

Sometimes as a student you are encouraged to believe what you see, that there is nothing below the surface and to carry on with the lesson. I want students to not only be intrigued by my product but *want* to dissect it. To figure out why that one gear is there and say that they understand. I remember *my* 7th grade science class. During a lesson about DC motors, I wish I could have seen more than a low resolution Youtube video explaining the concept. I've put a 9v battery up to a motor in the past, news flash it spins. But HOW does it spin. And why are today's components all based around the DC motor? It just felt like something was missing, this is the problem I am trying to solve.

# Design Brief / Specifications

***Create a teaching tool that visually illustrates the workings of common STEM related components.***

- Product should **INSPIRE** the younger generation of makers!

- Final product should be tinkerable, but still a teaching tool.

- STEM models will provide insight to how things work for multiple age groups and grade levels.

- Should work just like the real components, disregarding strength as these are more for show and teaching.

- ***Simulation of STEM content will be the focus in addition to the models displaying realistic attributes.***

- Product should be bigger than standard components. Have physical examples of the real components for comparison.

- Will largely be 3D printed, try to use colors, illustrating different components. (gears, housings, etc.)

- Design before doing. These components should be able to work in Fusion using joints and motion links before actually printing parts out.

- This avoids waste, plastic and my time. I am at a level of CAD that this should be achievable.

# Concept Map - Focus Area

-Who is my target demographic, how old are they?

-In my eyes a teaching tool for something a little more complex, falls into the middle school level of students.

-In the end, I want anyone to be able to utilize my product.

-I want curious people to use this product, deepen their understanding.

-Make a seemingly hard thing, EASY to understand.

-Do this visually, through deconstruction of said thing.

-Should be intuitive to use, same level of complexity as a LEGO set for example.

***Teaching Tools***

Target Demographics
Areas of Attention
General Goals for Tool
Individual Learners

-What area needs the most help. STEM?

-Display that aid in specific area has *needed* this kind of attention.

-How can I cater to different learning styles?

-Definitely something that can be researched heavily, people have been learning about how different students think for years.

-What kind of elements do I incorporate? Is it tactile, make sound, visually appealing?

# Concept Map - Idea

-All components will be designed in Fusion 360

-Components will be 3D printable. Not only to display the product but for the user having the option of printing individually.

-Choose materials wisely. Using bright colors could make the product more visually appealing.

-Print all major housing/shell components clear, so inner workings can be observed.

-Make a seemingly hard thing, EASY to understand.

-Do this visually, through deconstruction of said thing.

-Should be intuitive to use, same level of complexity as a LEGO set for example.

## *STEM Teaching Tool*

Manufacturing

How Its Used

Design Ideas

-Some sort of live demo for the real deal components.

-Some sort of numbering system to find out what the parts do and are.

Limit the complexity in how its put together, the less screws the better. Try to incorporate tabs for part assembly use PLA properties to my advantage.

Potential Components could be Servos, Linear actuators, D/C motors.

Final product should look and feel almost cartoonish. Fun to interact with and tinker.

# Design Mentor

My design mentor, **James Hitchings**, is a STEM teacher at Chatham Middle School. I felt his expertise in both my subject area and student demographic could greatly help with my project. So far, he has given me positive feedback on both my CAD models and how I can cater my designs to specific age groups. He suggested that I create some sort of key/guide that students can look carefully at. He explained that you need to hide an element of discovery in the product. For example, smaller arrows pointing at parts can actually be BETTER. It forces kids to analyze the material. I will continue to bounce ideas off of Mr. Hitchings and eventually present him with my final solution.

# Mentor Letter

SCHOOL DISTRICT OF THE CHATHAMS

CHATHAM HIGH SCHOOL
255 LAFAYETTE AVENUE
CHATHAM, NEW JERSEY 07928

Wll Volovich
Student of Design Studio
williamvolovich@chatham-nj.org

Dear Mr. Hitchings,

Hello! I am Will Volovich and I am a Senior at Chatham High School. For the last couple of years I have been pursuing engineering in school and personally. In school, I have taken all but one of Mr. Mariano's design classes, now I am taking a class called Design Studio, which is more of an independent study and design class. This is actually the second year I am participating in this class. Last year, my goal challenged me in prototyping and product design. This year, my focus will be toward sharing the study of STEM with various ages and grade levels in ways I feel are beneficial and foster interest in future enrollment in STEM fields.

I want to relate to the kind of student that is similar to myself. The student that is interested in STEM and is actively seeking out and exploring the world of invention and innovation. My idea is to create a teaching tool that visually illustrates the workings of common STEM related components. The design at its core, are scaled up and disassemblable versions of common engineering/robotics components. Imagine a linear actuator, bland and seemingly complicated. My product would imitate the functionality of this device but include diagrams, clear viewing ports, and colorful components to better illustrate how it works. This is just one of multiple components I am creating. I plan to model these in CAD and 3D print the final products. Here is why I am sending this letter. YOU are teaching my target demographic at the middle school level. As a teacher I believe that you might be more familiar with the "teaching tool" aspect of my project, and could provide some much needed feedback once I get going

Should you agree to participate in this design process, you will be communicating with me on one or two occasions providing me feedback on the designs and features I have come up with to solve my design challenge. Having feedback from a professional will give my design a higher quality. It also gives me the opportunity to learn from you. If you were to mentor me it would be a huge success and I hope you will help. Thank you!

Sincerely,

Will Volovich
Chatham High School
williamvolovich@chatham-nj.org
willvolovich.com

# Response from Mr. Hitchings

**James Hitchings** <jhitchings@chatham-nj.org>
to me

Hi Will,

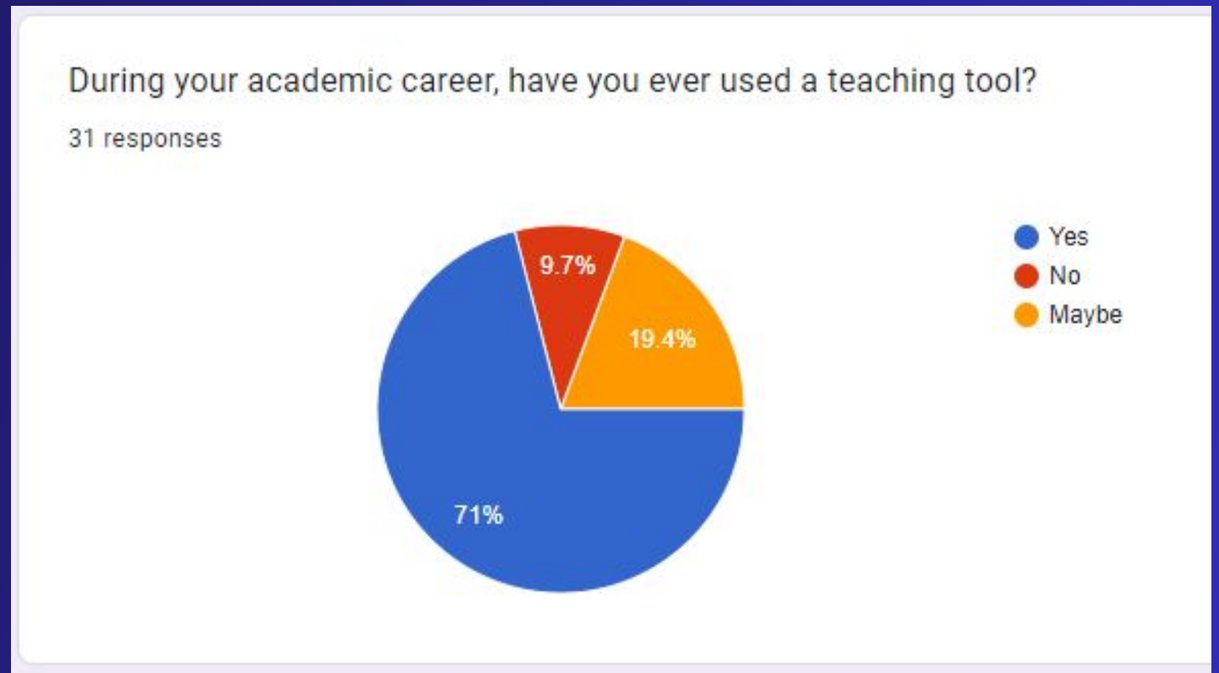
I'd be happy to help out. Let me know when you have some ideas together and you're ready for meeting.

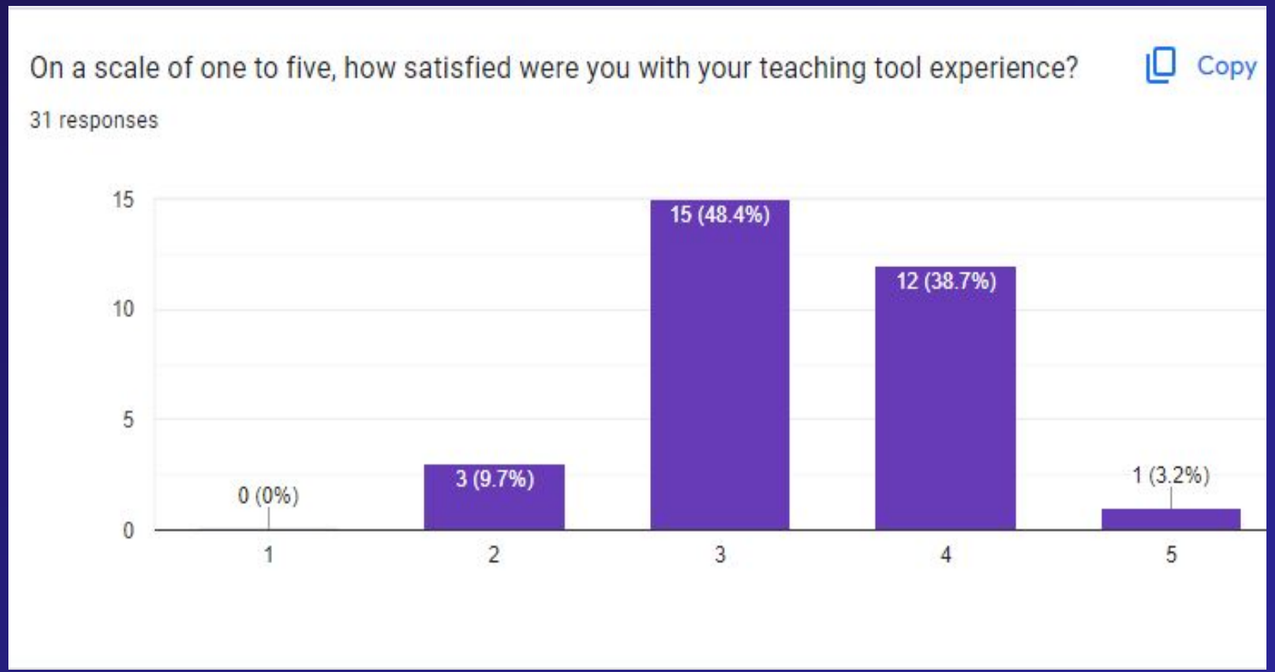
Thanks,
Mr. Hitchings 🐝
--
**James Hitchings**
Design & Technology Teacher
Chatham Middle School

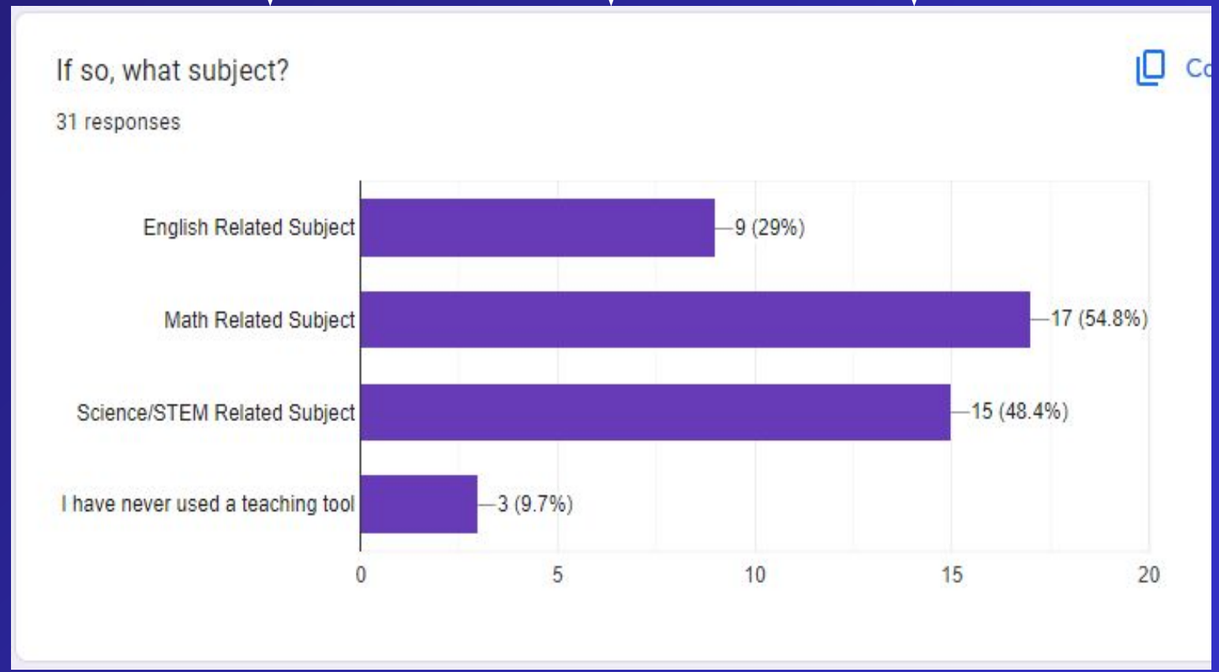
School District of the Chathams
Design & Technology

# Topic Survey

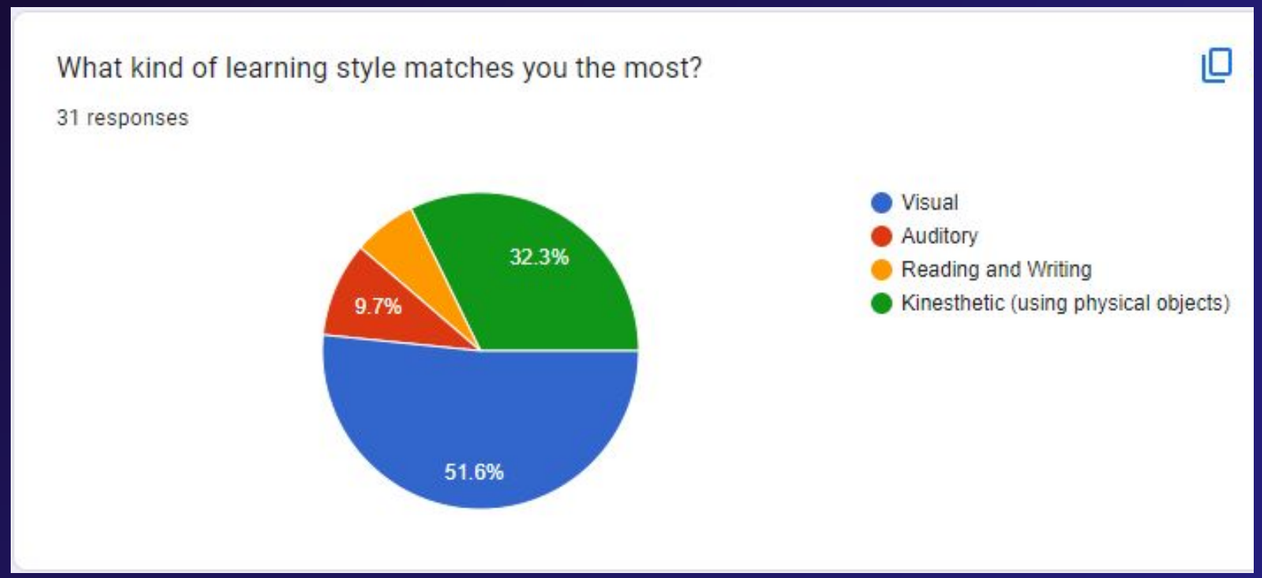
I conducted a survey to gauge the public understanding of teaching tools. Questions were kept very general, nothing specific about design. I wanted to better understand the knowledge that was already out there. These questions focus on a previous understanding of teaching tools, and satisfaction of the user experience. This information helped me get a feel of the project I was about to accomplish, and allowed me to gauge how people would feel about my choice to make a teaching tool.

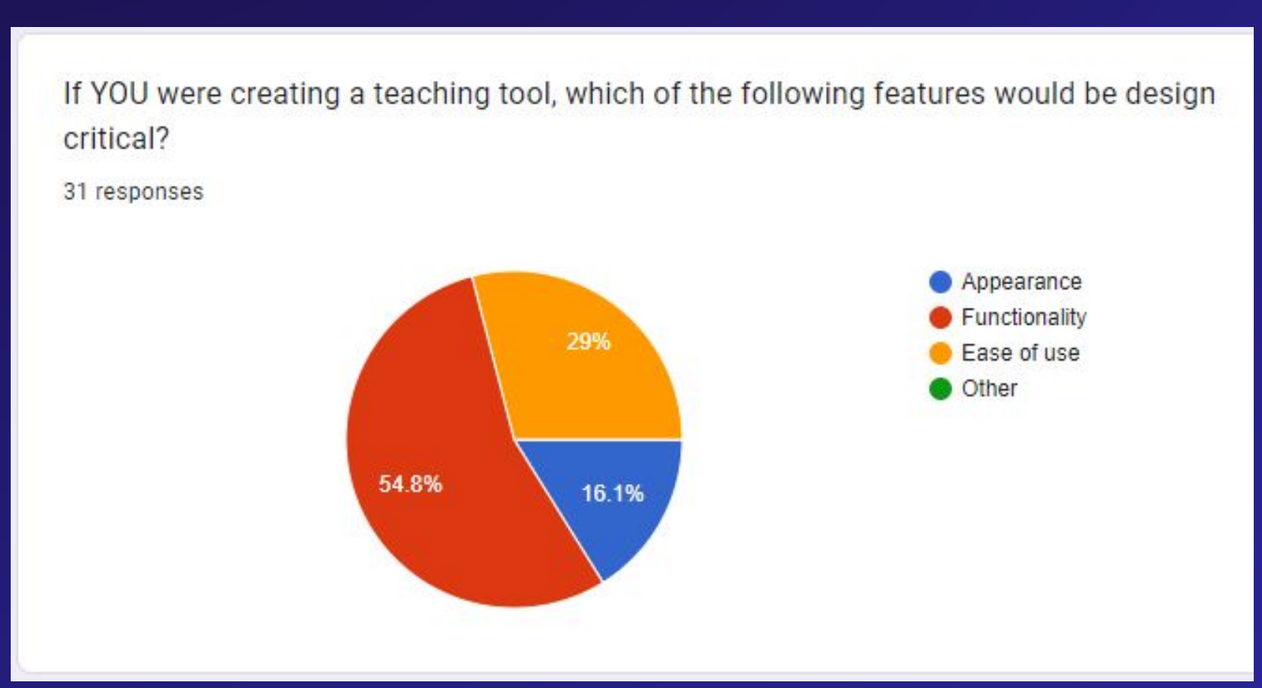


# Survey Results




These two questions address learning styles and important design features to include. Most people find themselves to be visual learners and appreciate the importance of a functioning product. This information cemented the idea of using color to make the product more visually appealing.

**Conclusion:**

Though it was brief, I learned a lot from this survey. I sought out the public opinion on teaching tools and now know what to hone in on while designing. My key focus points will include improving the product visually, having it function smoothly, and general improvement of user experience. The majority of responders had an lackluster experience when it came to using these tools, I will be looking to improve that. Zero responses choose to address the open ended question.

# Topic Research

**Expanded Knowledge on Teaching Tools**

- Should reflect on an existing understanding, this is where an example of a **linear actuator** can assist the user.
- Done through talks with my design mentor.
- Sort of **“hiding” the answer** from students can be a great way to keep them engaged while using the tool.
  - *Ex: Using a smaller font/directional arrows in a diagram or key, promoting the urge to look carefully.*

***Materials List***

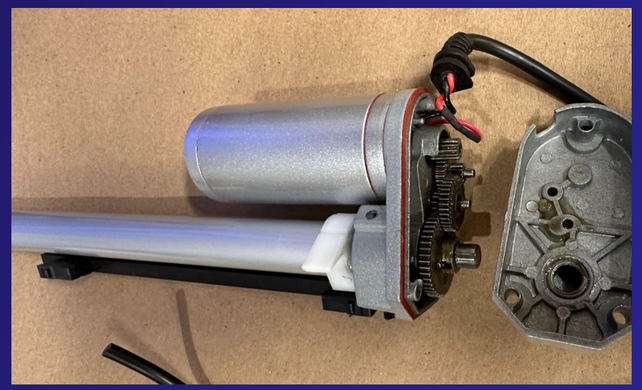
3D printing Filament

- Cater to my colorful philosophy
- Also buy plain colors for prototype drafting

Physical Components

- Linear Actuator (for comparison)
- Motors, harvesting two already from project R.A.L.P.(H)
- Lead screw/coupler


Video used to research clear printing profiles



Disassembled actual linear actuator to see inner workings. Reverse engineering.


Video used to understand putting together a GitHub

**Manufacturing**

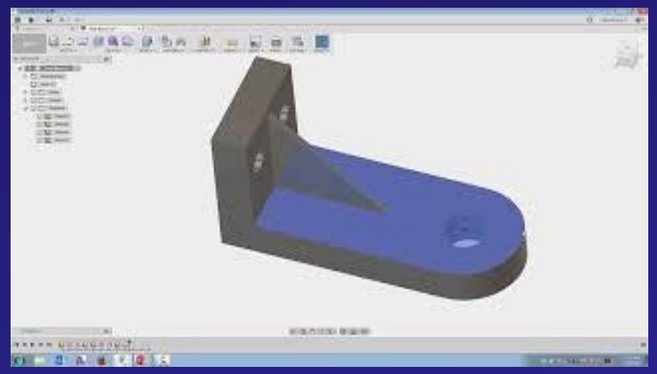
- Keep all prototypes, within reason. Showing the thought process.
- Possibly think about mass production, getting the product out to the world.
- **Having it be a potential classroom project, for any school with a 3D printer could be great.**
  - *This would be more work, but the result could seriously be implemented.*
- Vapor Smoothing clear PETG, for viewing purposes, better yet: modifying cura profiles to create transparent parts.
- **MY** knowledge of a linear actuator will mostly come from taking one apart myself, learning.
- Recently got Octoprint working on my printer. Use this to my advantage. **Maybe when it comes to putting the product together as a kit.**

***Favorite points are Highlighted***

# Topic Research

**Fusion 360**

- Learning how to create animations, and deconstructions of the final assemblies. Not only assisting the user but showing off my final product.
- **Technical drawings** can be useful for a key/guide, enhancing the user experience.
- ***WORKFLOW.*** Don't set myself back within my assembly, research how to do this.



**Fusion 360 Workflow Video**

**Cadasio**

- Fusion 360 plugin used for creating instruction manual.
- Originally discovered through Instagram
- Video breaks down the basics of using this software.


**Research Takeaways**

- I'd like to package a mock kit for display.
- Publish files on a website. Github? Follow the teaching for everyone philosophy.
- A key **needs** to be made. This is something that should be better than the actual product.

***Favorite points are Highlighted***

# Discussion period

***This slide was printed and read from during a feedback session with my peers. My goal was to convey the message of my product as I had little to show at the time.***

Problem Statement: **Create a teaching tool that visually illustrates the workings of common STEM related components.**

Talking Points:

*Inspiration:*

- Wanting to contribute more to the STEM community rather than to just myself.
- Taking inspiration from youtube. I've seen creators build their own linear actuators and components using 3D printing.

*Research:*

- Discovering the different aspects of teaching tools. Auditory, Visual, Kinesthetic…

*Aspirations:*

- I want this product to be approachable to kids. Target audience: Middle School.
- Potential classroom project, releasing the files.

*Design:*

- Body will be printed clear. For viewing of working components. Gears and inner components will be colorful.
- I plan to laser cut intricate boxes for packaging presentation, engraving a wireframe model.
- I plan on fully prototyping this out before I go to print the final.
- Herringbone gears, for non slippage.

***(Peer feedback written on paper during discussion)***

- Possible battery power?
- Be more clear with my projects end goal
- Really try to incorporate the educational aspects to this “product”, they would rather see this done then a super complex model
- How can this be more than a kit?

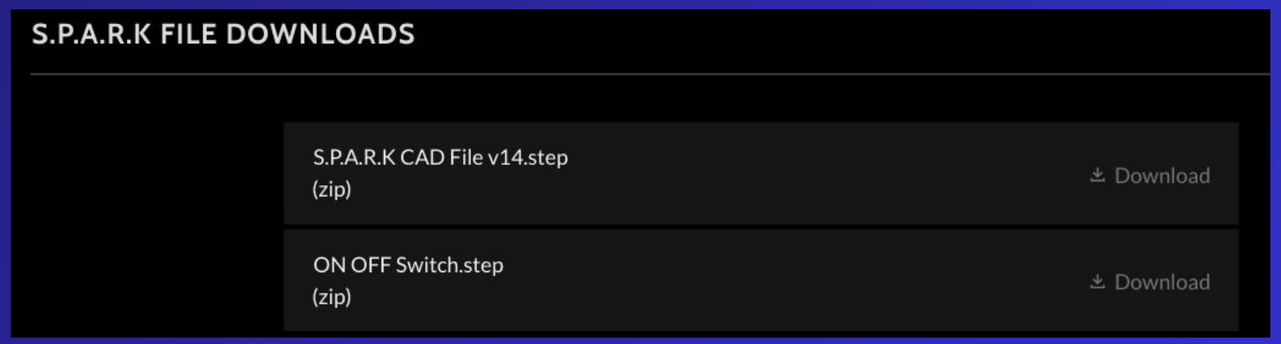
# Educational Aspects

To make learning easy, I created detailed instructions and a video on how to assemble this kit. ***This information can be accessed via the Project S.P.A.R.K page on willvolovich.com***. Creating these guides required me to think how my target audience would. I needed to ensure accurate assembly of the project without complicating information.

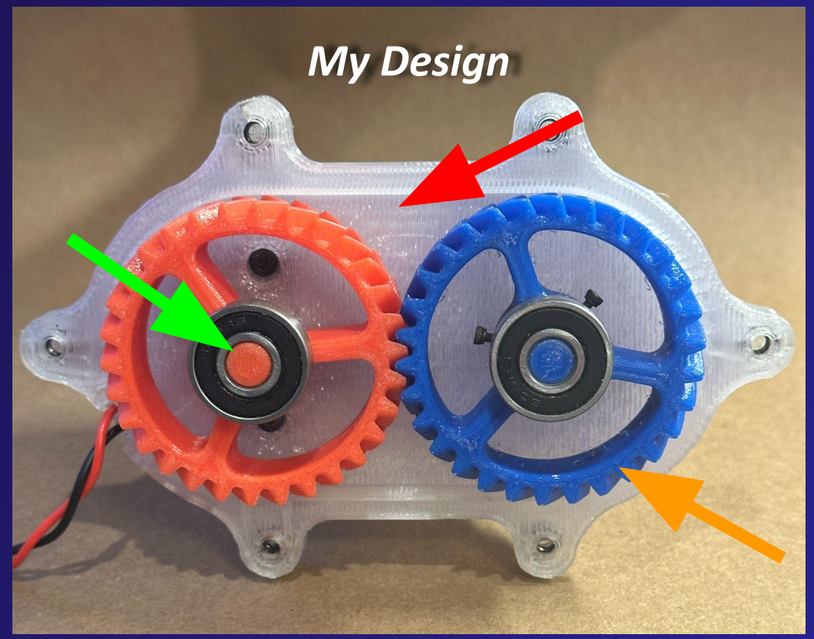
An additional aspect of this project is the ability for it to be 3D printed directly by the user. This enhances engagement as the project can be personalized to the user. They can pick their own colors, change print settings, and if applied to a classroom setting can keep kids engaged as they watch components print. These files can also be found on my website, along with a parts list of non-3D printable components.

*Frame from Instructional Video*

*Page From Assembly Guide*



# Inspiration


## *Design Similarities*

**Red**- Top Housing

**Orange**- Gears

**Green**- Rods/Support

The idea of 3D printing a linear actuator is nothing new. However I believe that the use of it also being a teaching tool is. I used many of the same design principles as other 3D printed examples and made it more of a finished product. My model implements helical gears, a see through body, and can be assembled in fewer steps.

In addition to this, I drew inspiration from a tutorial on using helical gears in Fusion 360. I was able to install a plugin and implement these gears into my design. I learned that dual sided helical gears do not slip/skip as easily, could be easily 3D printed, and quickly iterated on. These characteristics made choosing this gear design a no brainer.


***SPARK PLUG on Youtube***

***Plugin By: Ross Korsky***

# Possible Solutions

Different prototypes I went through designing this product

***Red***- Bottom Housings

***Blue***- Top Housings

***Green***- Gears

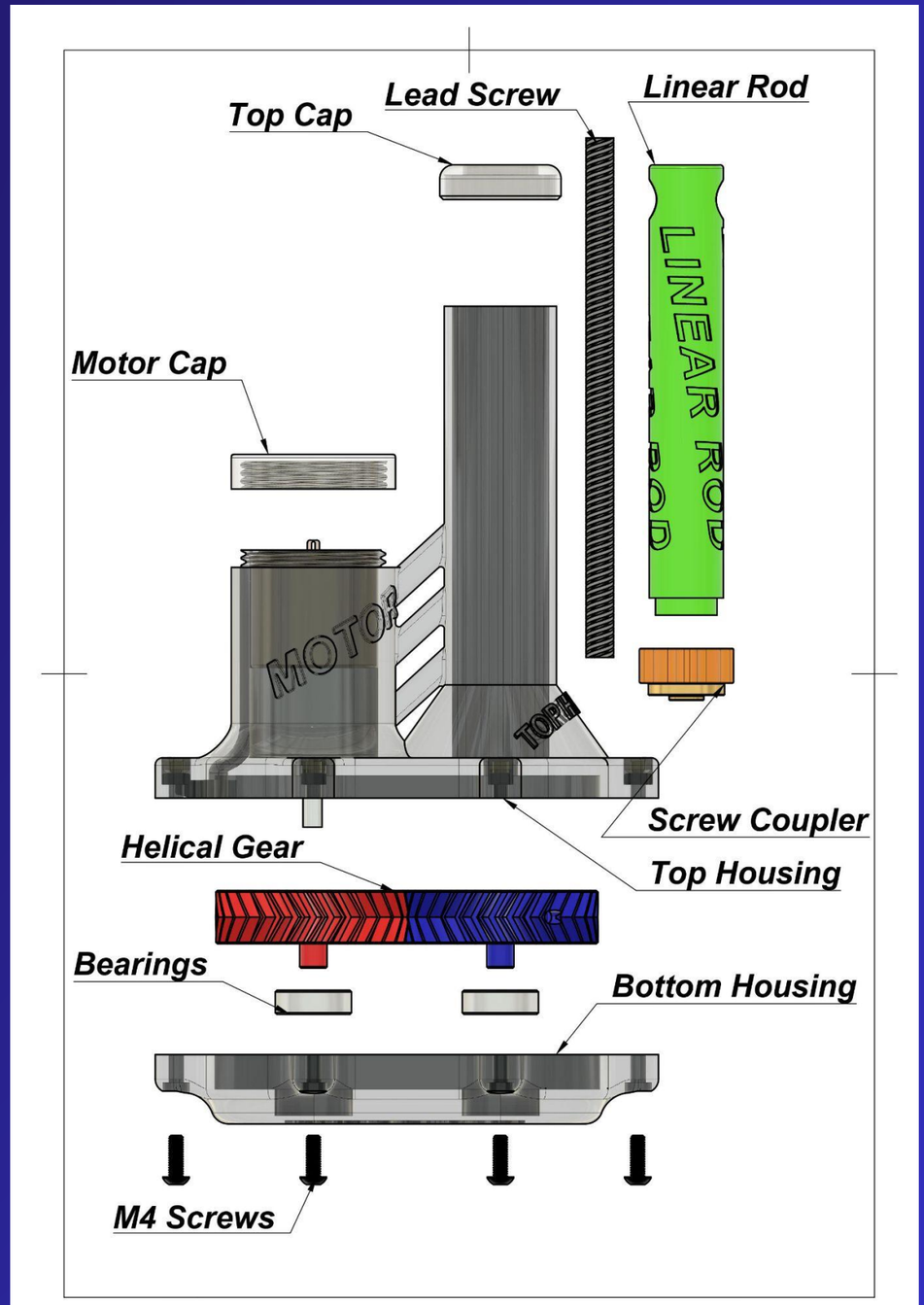
***Orange***- Threads

***Pink***- Linear Rod

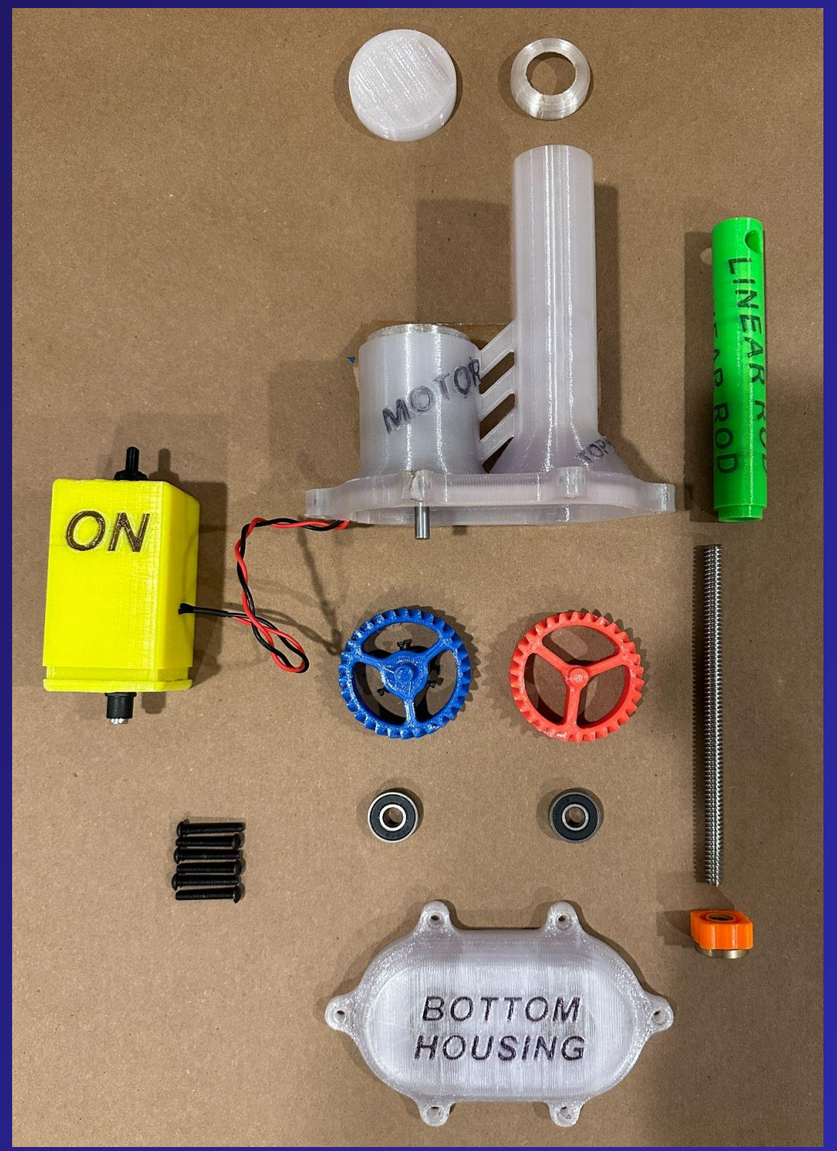
***Yellow***- Guide Caps

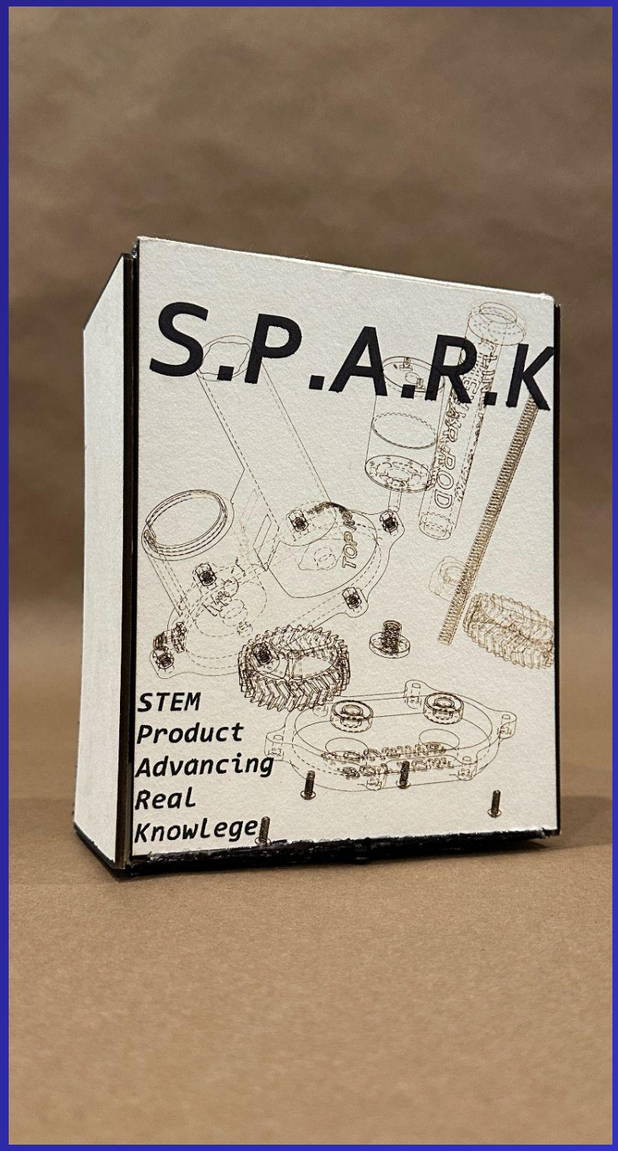
***Pink***- Lead Screw Couplers

# C.A.D/Drawings

# Final Solution


*Mock Advertisement on Next Page*

# (Final Solution)

# S.P.A.R.K


*Top Housing*

*Lead Screw*

*Helical Gears*

*Bottom Housing*

*M4 Screws*

**Classroom Projects that make a difference!**

**Purchase a kit or… Print it yourself!**

***Additional Information***

***STEM PRODUCTS ADVANCING REAL KNOWLEDGE***

# Summary

I approached my second year of design studio with lots of skepticism, the task of producing a project similar to last year daunted me. Despite this, I feel as if this time around I was able to produce a more meaningful project with a stronger message supporting it.

Applying all of my previous CAD knowledge in this project was incredibly beneficial to me. In comparison to my previous designs, there was little learning curve for me when using Fusion 360 along with zero design errors in the timeline. Because of this, I could properly retrace my steps when necessary and made redesigning major components easy. This time saved on design allowed me to implement educational aspects that I thought would greatly benefit the end product. Taking a step away from the CAD and 3D printing to make my assembly video was refreshing, and reinforced the final presentation immensely. Because of my passion for this project, talking about it during the showcase day came easy for me. I was able to strongly convey my message and received nothing but positive feedback.

All said and done I feel that I was 70% of the way towards a final product, my message was absolutely conveyed. With that being said I am more than happy to have hit this mark. I was able to almost make four sub-projects. Between the prototype, video, instruction guide, and download page. The groundwork has been laid if I were to continue further down the path that has been project S.P.A.R.K. If I wanted to take this product to the next level I would need to consider a multitude of different factors. How much would my product cost? This question arose during our gallery walk and had never even crossed my mind during the whole semester. Little details like this is what would take this project beyond the walls of Design Studio.

Taking this class was once again a pleasure. In my opinion, it was actually more difficult the second time around. My knowledge base when it comes to engineering is currently at its all time high. Everytime I accomplished one thing during this project I wanted to try to improve it and try alternative approaches. This was something I needed to overcome by telling myself that whatever I had was good enough. I know that this trait will only benefit me in a college or professional setting and I never would have adapted it if it was not for Design Studio.