Engineering Notebook

By: Aaron Minard

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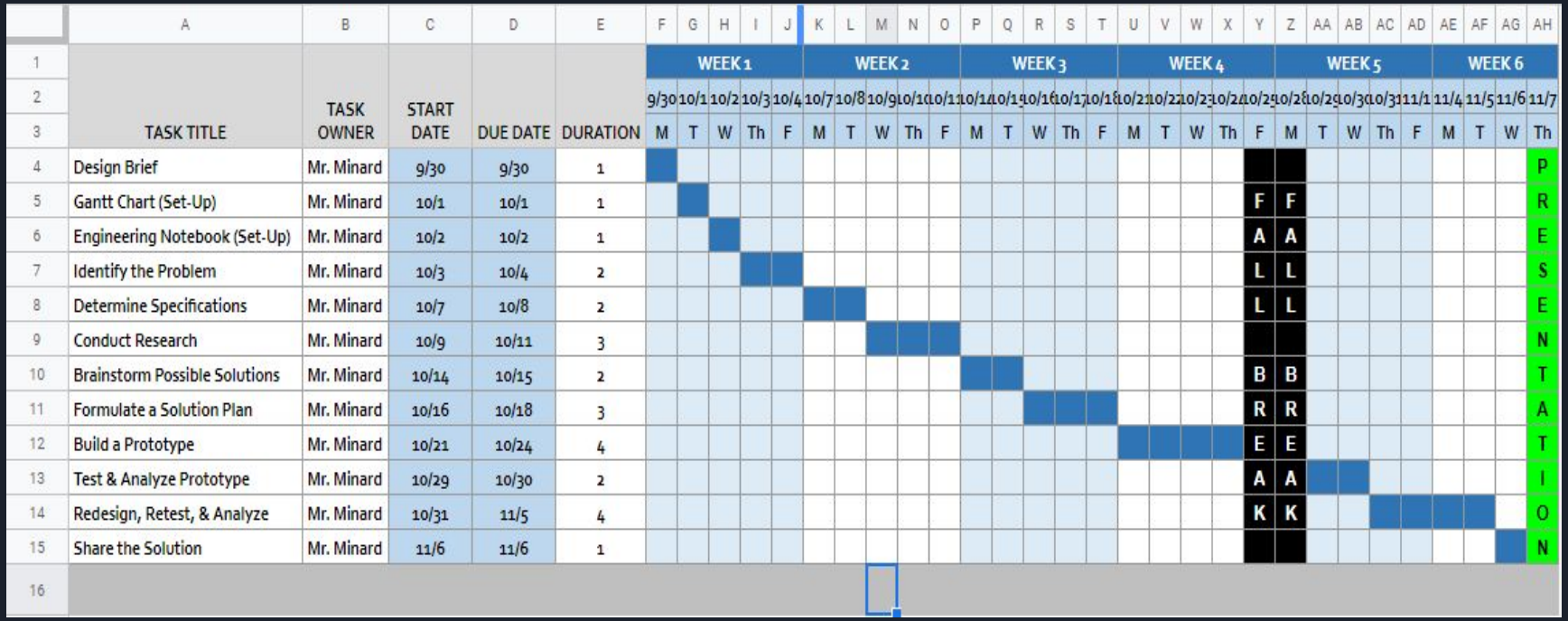
The Challenge

Design and create a solution to an everyday problem in your life, your community, or your school by way of the engineering design process.

Gantt Chart



TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION
Design Brief	Mr. Minard	9/30	9/30	1
Gantt Chart (Set-Up)	Mr. Minard	10/1	10/1	1
Engineering Notebook (Set-Up)	Mr. Minard	10/2	10/2	1
Identify the Problem	Mr. Minard	10/3	10/4	2
Determine Specifications	Mr. Minard	10/7	10/8	2
Conduct Research	Mr. Minard	10/9	10/11	3
Brainstorm Possible Solutions	Mr. Minard	10/14	10/15	2
Formulate a Solution Plan	Mr. Minard	10/16	10/18	3
Build a Prototype	Mr. Minard	10/21	10/24	4
Test & Analyze Prototype	Mr. Minard	10/29	10/30	2
Redesign, Retest, & Analyze	Mr. Minard	10/31	11/5	4
Share the Solution	Mr. Minard	11/6	11/6	1

Identifying the need or problem

- Students are accidentally burning themselves while using hot glue guns.
- The hot glue guns don't stay upright.
- The hot glue gun cords get in the way while students are gluing material together.
- The hot glue gun power cords get tangled and twisted together.
- The hot glue gun station gets crowded.
- Glue gets all over the table.

- Who - Students are affected by this problem.
- What - The issue is that students burn their fingers, hands, or arms when they come into contact with the hot metal tip of the hot glue gun.
- When - This occurs when students are using the hot glue station to glue materials together such as cardboard, wood, metal, and plastic.
- Where - This issue is occuring at the hot glue station.
- Why - It's important to find a solution to this problem so that students are less likely to burn themselves while using hot glue guns.

Identifying the need or problem (continued)

Problem Statement:

A hot glue gun is a convenient, inexpensive, and useful tool for students to join materials such as cardboard, wood, metal, and plastic together for small projects and craftwork. Unfortunately, while using these hot glue guns, many students are burning their fingers, hands, and arms when they come into contact with the hot glue and/or the hot metal tip of these hot glue guns. A product and/or a process that helps to keep the hot glue and the hot tip of the hot glue guns pointed away from the students will minimize the number of skin burns.

Determining Specifications

Criteria:

- Device must be compact enough to allow adequate workspace for gluing.
- Device should be stable enough not to tip over while in use.
- Device should be versatile enough to accommodate various glue gun models.
- Hot glue gun must be secure while not in use.
- Hot glue gun should be easily accessible.

Constraints:

- Device must be made with low-budget materials.
- Workstation is limited to a 2’ x 5’ metal working surface.
- Workstation is only accessible from 3 sides because it is up against a wall.
- There’s only enough room for 3 or 4 students per table.
- The hot glue gun only works when it’s plugged into an electrical outlet.

Research

Operating Precautions:

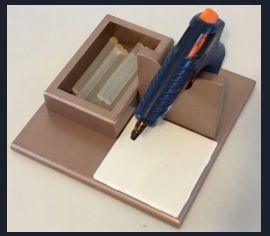
- Always wear protective clothing overalls or long sleeve shirts, closed-toe shoes, heat resistant gloves, and safety glasses or goggles. Keep long hair tied back.
- Make sure the work area is clean, dry, and clear of flammable materials and loose cables.
- Never lay a hot glue gun on its side. Store the glue gun in a safety stand.
- Always use a drip mat. This will help to catch hot glue drips and prevent damage to underlying surfaces.
- Never leave a hot glue gun unattended, especially while plugged in. Unplug the glue gun if you're not going to use it for over 40 minutes.

Resource: https://www.gluegunsdirect.com/service-and-advice/glue-gun-safety-advice/

Research (continued) - Existing Solutions

Existing Solutions:	Reviews and Features:	Resource:
	This stand is way too lightweight! You need to place the glue gun gently on it or it will fall over.	https://www.hobbylobby.com/Crafts-Hobbies/Basic-Crafts/Glues-Adhesives/Glue-Gun-Stand/p/23515
	Removable plastic upright is great for storage but it doesn't stay in place while in use.	https://www.amazon.com/Sizzix-662302-Accessory-Stand-Multicolor/dp/B07CD9XBNZ/ref=sr_1_1?keywords=glue+gun+stands&qid=1571573242&sr=8-1
	Strong, sturdy, and holds glue gun perfectly. Heat resistant glass makes for easy removal of dried glue. Also holds glue sticks. Poor craftsmanship though.	https://www.amazon.com/Totally-Tiffany-HGGH19-WHT-Hot-Glue-Holder/dp/B01FGG2V6S/ref=sr_1_4?keywords=glue+gun+stands&qid=1571574111&sr=8-4

Research (continued) - Existing Solutions

Existing Solutions:	Reviews and Features:	Resource:
	Not durable. Product is made of very thin balsa. The design is good but too flimsy and must be glued together.	https://www.amazon.com/Handmade-Glue-Gun-Station/dp/B07FK1TMK9/ref=sr_1_17?keywords=glue+gun+holder&qid=1571575129&sr=8-17
	Product has a “V” shape to hold any standard sized hot glue gun. Tile is helpful to catch glue for easy removal. There are also rubber bumpers under the stand to prevent it from sliding.	https://www.etsy.com/listing/226977033/hot-glue-gun-stand-golden-oak-stain?ga_order=most_relevant&ga_search_type=all&ga_view_type=gallery&ga_search_query=glue+gun+stand&ref=sr_gallery-1-20&pro=1&frs=1
	Product is compact (9” x 9”) and includes a shallow glue storage box for easy access and a porcelain tile to catch glue drips for easy removal.	https://www.etsy.com/listing/701349189/hot-glue-gun-stand-with-glue-stick?ga_order=most_relevant&ga_search_type=all&ga_view_type=gallery&ga_search_query=glue+gun+stand&ref=sr_gallery-1-19&frs=1

Research (continued) - Measurements

Hot Glue Gun (White)	Hot Glue Gun (Blue)	Multiple Outlet Strip	Work Station (Metal Table)
Length - 4 ½ “	Length - 4 ½ “	Length - 9 ¼”	Length - 60“
Width - 4”	Width - 4”	Width - 3 ¼”	Width - 24”
Thickness - 1 1/16”	Thickness - 7/8”	Height - 1 ⅝”	Height - 32”
Cord Length - 60”	Cord Length - 52”		

Research (continued) - Investigation

I cut two different sized slots into a scrap piece of wood to help me determine an appropriate slot size that will accommodate my two different hot-glue gun styles.

Slot A - 1 1/16” x 2”

Slot B - 1 3/16” x 2”

I placed each glue gun in each of the different sized slots to determine best fit.
Slot A - Good Fit
Slot B - Too Loose

I raised and lowered the slotted upright to determine a good height. Three inches seemed like a good height.

Research (continued) - Research Summary

Research Summary:

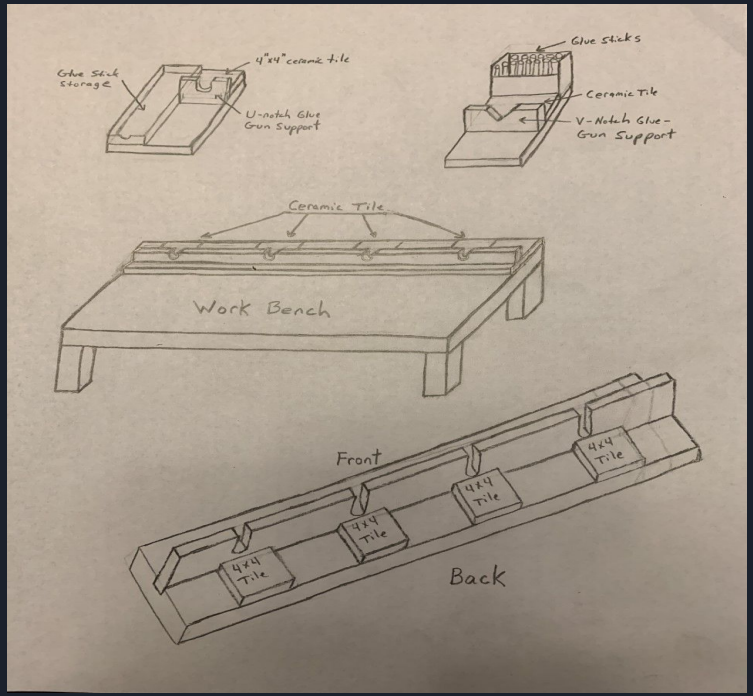
In order to reduce the risk of burns inflicted by hot glue guns, it is recommended that protective clothing such as long sleeve shirts, gloves, and safety glasses be worn. The hot glue station work area should be clear of debris, flammable materials, and loose cables. It is also recommended that glue guns be stored upright in a safety stand rather than laying them on their side. These safety stands are typically made of wood, metal, or plastic and contain a slot or notch for the hot glue gun to fit into. Additionally, some safety stands also come with a drip mat to catch hot glue drips to prevent damage to underlying surfaces.

Brainstorming possible solutions

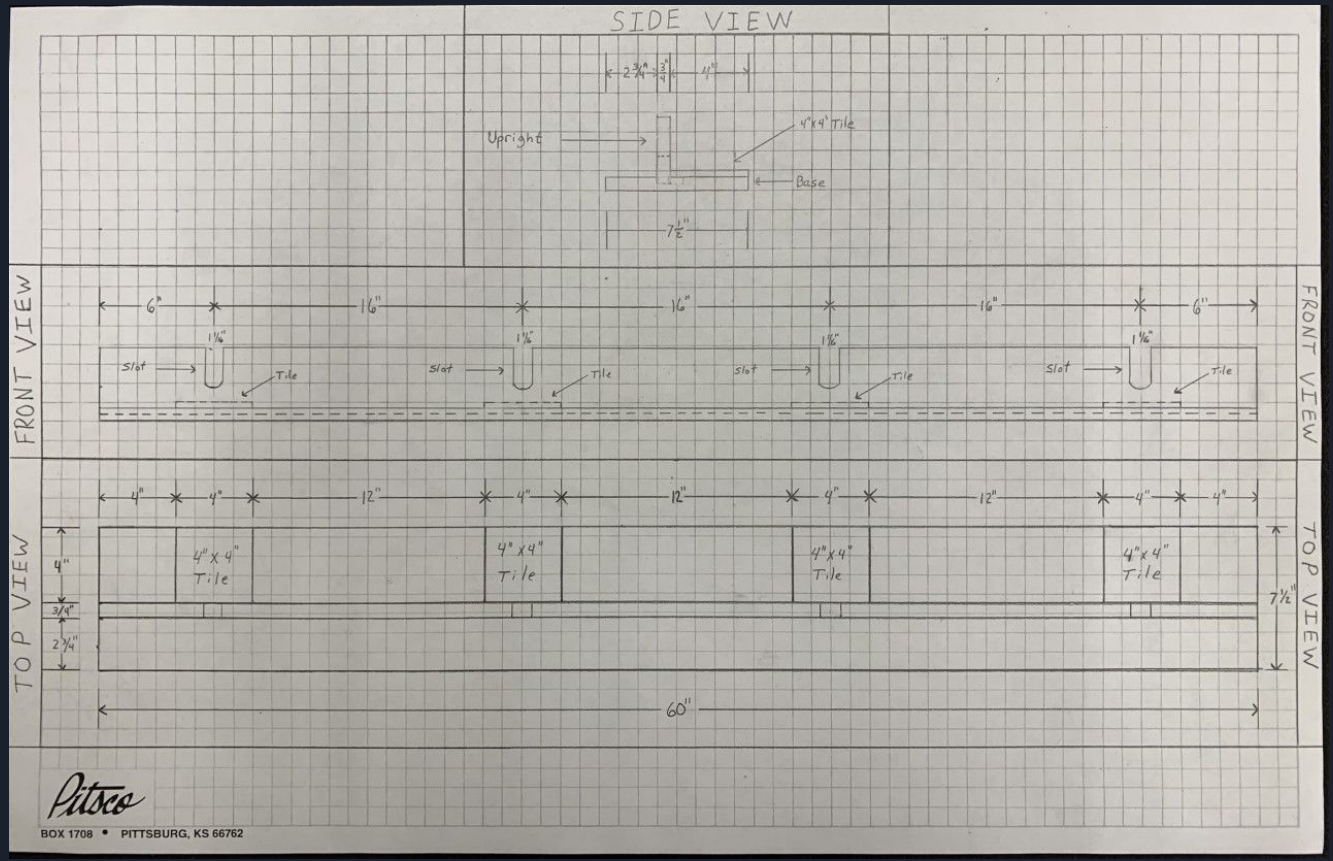
Top Left:
Individual glue gun stand with built in glue stick storage tray, U-notch upright, and a 4” x 4” ceramic tile to catch glue drips.

Top Right:
Individual glue gun stand with built in glue stick storage bin, V-notch upright, and a 4” x 4” ceramic tile to catch glue drips.

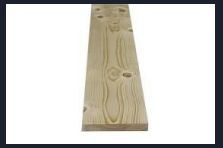
Middle & Bottom:
A 4-person table-top glue gun stand with (4) U-notches and (4) 4” x 4” ceramic tiles to catch glue drips.



Formulating a Solution to Implement - Blueprint



Formulating a Solution to Implement - Materials

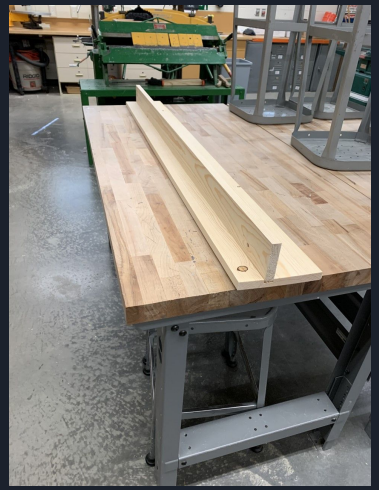
Quantity:	Description:	Image:
1	1” x 8” x 6’ pine board	
1	1” x 4” x 6’ pine board	
4	4” x 4” ceramic tiles	
1	Tube of Gorilla Glue	
1	Bottle of wood glue	

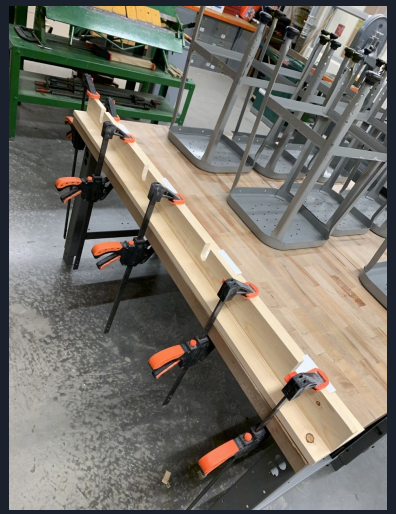
Formulating a Solution to Implement - Procedures

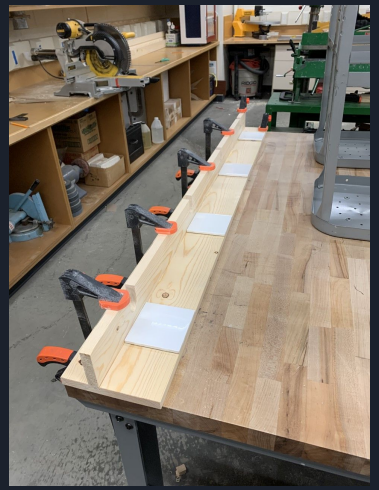
Step-By-Step Building Procedures:

1. Using the radial arm saw, cut each board to a length of 60 inches to match the length of the hot glue work station table.
2. Using the table saw and a ¾" dado blade, cut a dado down the length of the 1" x 8" x 60" board that is ⅜" inch deep and 4" away from one edge of the board.
3. Mark and drill four 1 1/16" holes into the 1" x 4" x 60" board exactly 2" from one edge of the board at each of the locations indicated on the blueprint to serve as the base of each slot .
4. Using a scroll saw, cut each of the holes into elongated slots as indicated on the blueprint.
5. Using a drum sander, sand each slot until smooth.
6. Glue the non-slotted edge of the 1" x 4" x 60" board into the dado joint of the 1" x 8" x 60" board using wood glue, being sure to line up the ends of both boards, and then clamping them down using bar clamps until the glue is dry.
7. Using Gorilla Glue, glue each tile onto the 1" x 8" x 60" board right below each slot on the wider side of the bottom board.

Building a Prototype







Testing and Analyzing the Solution

Tested Variables:	Observation Data:
Size Is the solution compact enough to allow adequate workspace for gluing?	I observed many students using the glue station to glue their solar car projects together and it appeared that they had enough space to work around the hot glue gun stand.
Stability Is the solution stable enough not to tip over while in use?	The hot glue gun stand never appeared to be unstable while in use or when stationary. Occasionally, the stand would slide forward about an inch or so while in use.
Versatility Is the solution versatile enough to accommodate various glue gun models?	I observed two different glue gun models being used in the hot glue gun stand and they both remained upright when not in use.
Accessibility Does the solution allow easy access to the hot glue guns?	Three of the four slots equipped with hot glue guns appeared to be easily accessible by all students who used them. The fourth slot was a little too tight for one of the hot glue gun models.

Testing and Analyzing the Solution

Tested Variables:	Observation Data:
Glue Gun Security Does the solution secure the hot glue guns while not in use?	The hot glue guns never fell out of their slots while not in use. A few students left the hot glue gun on the table rather than placing it back into the designated slot.
Clear and Uncluttered Workspace Does the solution help to keep the workspace free and clear of clutter?	The workspace of the glue gun station was taken up by the students projects, the hot glue gun cords, and the hot glue stick container.
Overcrowding Does the solution help to minimize the overcrowding of students?	I observed, at most, five students at the glue station at one time. The fifth student was wrapped around the side of the table and didn't appear to be in the way.
Cleanliness Does the solution help to minimize the amount of glue drips on the table?	Most of the glue drips were found on the tiles attached to the back of the hot glue gun stand. However, when the students forgot to put the hot glue gun back, glue drip spots were found on the table. One student burned their finger on a glue drip.

Testing and Analyzing the Solution

Tested Variables:	Data Analysis:
Size Is the solution compact enough to allow adequate workspace for gluing?	The workspace area is approximately 15” x 18” per student at the hot glue station. It appears to be an adequate amount of workspace for the students that I observed using it.
Stability Is the solution stable enough not to tip over while in use?	The base of the hot glue gun stand has approximately 3 sq. ft. of surface area and appears to be quite stable while in use. The forward sliding of the glue gun stand was minimal but may need to be addressed.
Versatility Is the solution versatile enough to accommodate various glue gun models?	The hot glue gun stand was able to accomodate two different models of hot glue guns.
Accessibility Does the solution allow easy access to the hot glue guns?	Accessibility of the hot glue guns was adequate with the exception of one slot that was too tight and will need to be modified.

Testing and Analyzing the Solution

Tested Variables:	Data Analysis:
<u>Glue Gun Security</u> Does the solution secure the hot glue guns while not in use?	While the hot glue guns varied slightly in widths, the hot glue gun stand was able to secure all tested hot glue guns vertically while not in use. Since there were a few students who forgot to place the glue gun back into the designated slot when they were finished, a best practice process will have to implemented.
<u>Clear and Uncluttered Workspace</u> Does the solution help to keep the workspace free and clear of clutter?	Since the hot glue gun cords and hot glue stick container were cluttering up the workspace some modifications to the hot glue gun stand will need to be made.
<u>Overcrowding</u> Does the solution help to minimize the overcrowding of students?	The four designated slots, evenly spaced apart, kept the number of students at the table to four people most of the time. The solution seems adequate to minimize overcrowding.
<u>Cleanliness</u> Does the solution help to minimize the amount of glue drips on the table?	With the exception of a few students forgetting the put the glue guns back into their designated slots, the solution definitely minimized the amount of glue drips found on the table.

Testing and Analyzing the Solution (continued)

Synopsis of how my design addressed the identified problem:

My first prototype of the hot glue gun stand was moderately successful in keeping the hot elements of the hot glue guns away from my students fingers, hands, and arms. The hot glue gun stand was deemed fairly adequate for size, stability, versatility, accessibility, and its function in minimizing the overcrowding of students. However, the hot glue gun station was a bit cluttered with all the cords and a large container of hot glue sticks. There were also a few hot glue drips found in the workspace from the hot glue guns that were laying down and not being placed back into their designated slots when not in use. This caused one student to burn his finger on the hot glue.

Redesigning, Retesting, and Analyzing

Prototype improvement plan based on test results:

Tested Variables:	Data Analysis:	Improvement Plan:
Stability	The forward sliding of the glue gun stand was minimal but may need to be addressed.	I will place a c-clamp on both ends of the hot glue gun stand to keep it from sliding forward.
Accessibility	Accessibility of the hot glue guns was adequate with the exception of one slot that was too tight and will need to be modified.	I will use a drum sander to widen the slot that was too tight to accommodate the hot glue gun.
Glue Gun Security	There were a few students who forgot to place the glue gun back into the designated slot when they were finished.	I will re-teach the hot glue gun best safe practices lesson that will include placing the hot glue guns in the stand when not in use.

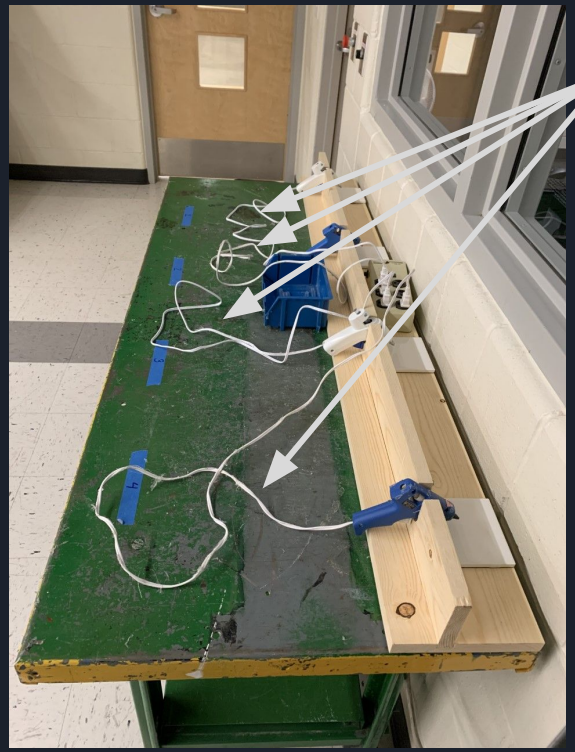
Redesigning, Retesting, and Analyzing

Prototype improvement plan based on test results:

Tested Variables:	Data Analysis:	Improvement Plan:
Clear and Uncluttered Workspace	Since the hot glue gun cords and hot glue stick container were cluttering up the workspace some modifications to the hot glue gun stand will need to be made.	I will redirect the hot glue gun cords under the table and make two small hot glue stick containers that can be attached to the hot glue gun stand to free up some of the cluttering of the workspace.

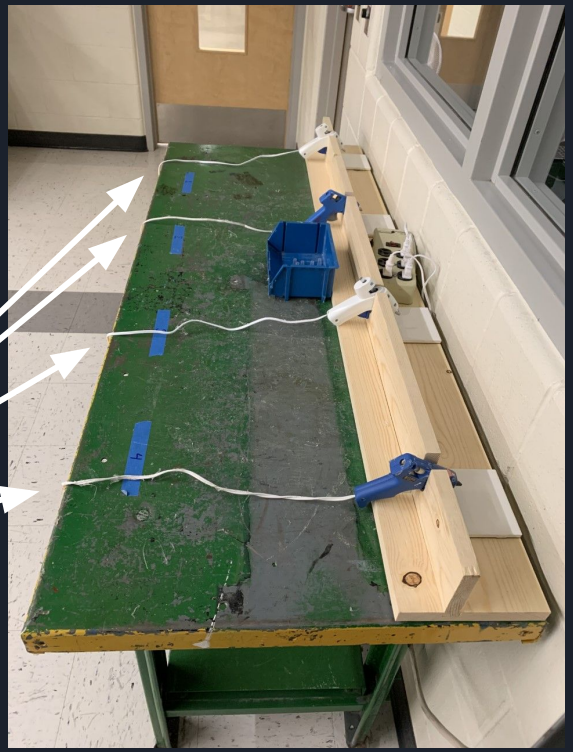
Redesigning, Retesting, and Analyzing (cont...)

Labeled diagrams for adjustments made:



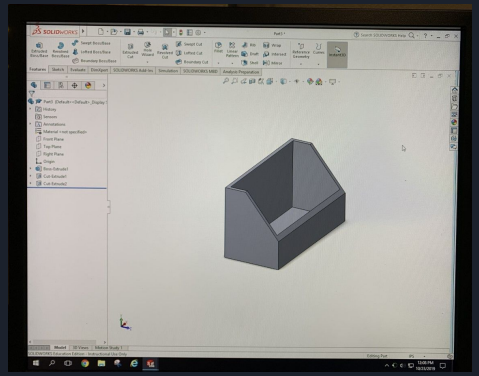
Cords routed on top of the table cluttered up the workspace.

I rerouted the cords underneath the table top to declutter the workspace.



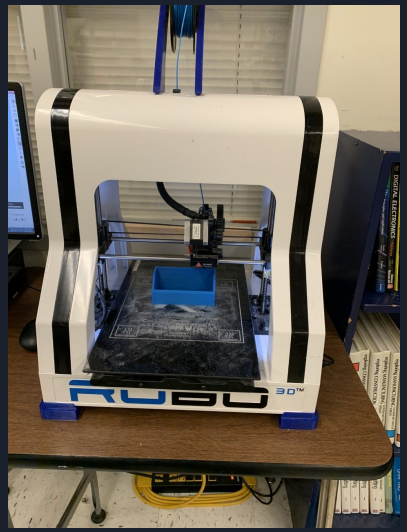
Redesigning, Retesting, and Analyzing (cont...)

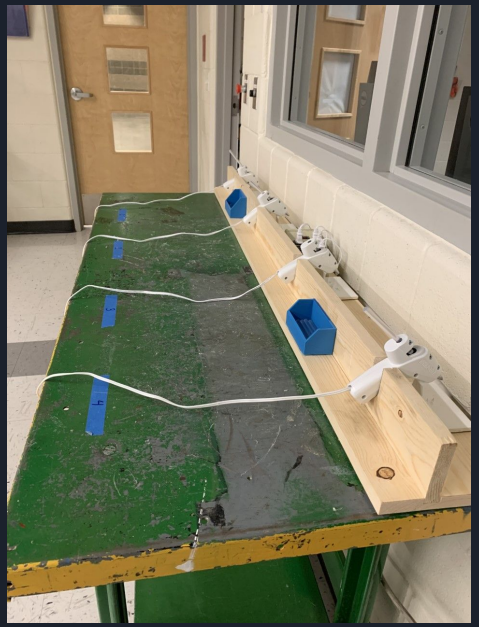
Labeled diagrams for adjustments made:



I designed a smaller glue stick container using the SolidWorks CAD program to be attached to the glue gun stand in order to minimize the clutter.

I printed two glue stick containers using my 3D printer.



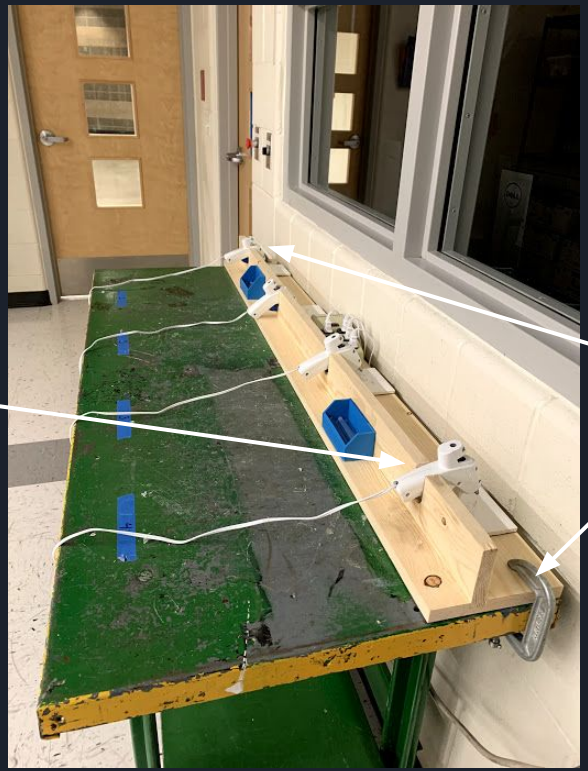


I attached the containers to my hot glue gun stand using Gorilla glue.

Redesigning, Retesting, and Analyzing (cont...)

Labeled diagrams for adjustments made:

I used a drum sander to widen the fourth slot to make it a little easier to insert the glue gun.



I attached a c-clamp to both ends of the hot glue gun stand to prevent it from sliding forward.

Redesigning, Retesting, and Analyzing (cont...)

Observations and data from retesting:

Tested Variables:	Observation Data:
Stability Is the glue gun stand stable enough not to tip over or “slide forward” while in use?	The glue gun stand remained stable and stationary during the re-testing phase.
Accessibility Does the solution allow easy access to “all” the hot glue guns?	All four slots equipped with hot glue guns appeared to be easily accessible by all students who used them during the re-testing phase.
Glue Gun Security Do the students secure the hot glue guns onto the stand while not in use?	Most of the students secured the hot glue guns onto the stand right before leaving the glue station but only a few students secured them between intermittent uses while working at the table.
Clear and Uncluttered Workspace Does the new solution help to keep the workspace free and clear of clutter?	The glue station remained free and clear of clutter from glue stick containers and cords. Workspace was occupied by student projects and a few hot glue guns laying on their sides.

Redesigning, Retesting, and Analyzing (cont...)

Analysis of new data:

Tested Variables:	Data Analysis:
Stability Is the glue gun stand stable enough not to tip over or “slide forward” while in use?	The glue gun stand is stable enough not to tip over due to the large surface area of the base and stationary enough not to slide forward due to a secure attachment to the table by two c-clamps.
Accessibility Does the solution allow easy access to “all” the hot glue guns?	The hot glue gun stand allowed easy access to “all” hot glue guns after widening the u-notch that was too tight.
Glue Gun Security Do the students secure the hot glue guns onto the stand while not in use?	My students have already formed a habit of laying the hot glue guns down during use and will need reminders and more practice placing them into the stand for safe keeping while not in use.
Clear and Uncluttered Workspace Does the new solution help to keep the workspace free and clear of clutter?	The new smaller glue stick holders attached to the glue gun stand along with the rerouted cords helped to minimize the amount of clutter in the workspace.

Redesigning, Retesting, and Analyzing (cont...)

Synopsis of how my redesign addressed the identified problem:

By securing the glue gun stand to the table with c-clamps, making all glue guns more easily accessible, and decluttering the workspace from the large glue stick container and cords, the functionality and ease of use of the glue gun workstation helped to minimize the risk of skin burns to my students.

Communicating the Solution - Conclusion

My first prototype of the hot glue gun stand was moderately successful in keeping the hot elements of the hot glue guns away from my students fingers, hands, and arms. The hot glue gun stand was adequate for size, stability, versatility, accessibility, and its function in minimizing the overcrowding of students. However, the hot glue gun station was also a bit cluttered with all the hot glue gun cords and a large container of hot glue sticks getting in the way. There were also some hot glue drips found on the table from the hot glue guns that were being laid down and not being placed back into their designated slots when not in use. This caused one student to burn his finger on the hot glue. Additionally, the glue gun stand also moved slightly forward, towards the students, while in use. Improvements were made to the original solution by redirecting the hot glue gun cords under the table, replacing the large glue gun container with two smaller 3D printed containers, re-teaching hot glue gun best safe practices, and securing the glue gun stand to the table with c-clamps to improve the functionality and ease of use of the glue gun workstation. The modifications made to the original solution were much more effective in minimizing the risk of skin burns when the students remembered to place the hot glue guns onto the stand intermittently between uses and again when they were finished at the glue station.

Reflection

The engineering design challenge allowed me and my students to experience real-world problem solving through the lens of an engineer. Utilizing the engineering design process as a step-by-step guide to go from problem to solution was both efficient and effective. I also liked how the engineering notebook helped us to keep a detailed account of each step of our projects from the initial brainstorming to the final data analysis. This challenge also covered a wide range of standards including seven of the eight common core mathematical practice standards and all four NGSS Engineering Design & Technology Standards. The design process that we used was the Pitsco Education design process because that's the process I've been teaching for the past four years. However, having worked through the Pitsco Education design process with my students I'm thinking that the NASA design process (Ask, Imagine, Plan, Create, Test, Improve) may be more intuitive for middle school students. Since I like to keep things simple I will most likely be modifying our design process but I will definitely continue to use the engineering design challenge activity as a lesson in engineering and problem solving for my students for many years to come.