B.U.N.J.E.E.

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5/22/2025

B.U.N.J.E.E.

Motivation[1]

Mobility aids allow individuals to maintain their independence, so that their quality of life isn't as greatly affected by a mobility issue. Running errands, going on walks, and other physically exhaustive activities can be done without fear of fall-based injury or the need to take extremely frequent breaks. Individuals whose mobility difficulties fluctuate in frequency do not always want to bring a bulky mobility aid, however, and Commit to the Byte intends to make a more accessible and portable option for walking support. The B.U.N.J.E.E. design can be used by all users who require a stability aid, such as individuals with POTS and/or syncope.

Problem Statement[2]

People who commonly experience syncope/limited mobility often need to rely on others to stabilize them. If they faint, they might fall and injure themselves. Additionally, past aids such as benches are no longer as viable in the present, as both indoor and outdoor seating have decreased substantially following COVID-19. This reduction is partly due to shop owners hoping to decrease the spread of disease, as well as limit availability to homeless individuals (Nguyen, 2023). In open areas, surrounding assistance is fully unavailable, so the risk of fall-based damage from suddenly feeling faint/weak cannot be avoided. Many current designs for personal seating/support, like a cane or chair, are not easily portable, leading to potential accidents due to their inaccessibility.[3]

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[1] Written by Caroline Walczak 5/6/25
[2] Written by Caroline Walczak 5/5/25
[3] Edited by Anthea Sun 5/9/25

Target Audience[4][5]

Our target audience includes adults who struggle with limited mobility to any degree. Limited mobility is a pertinent issue faced by millions of people, with 10.1% experiencing mobility issues to varying degrees (Iezzoni et al., 2001). With varying intensity or frequency, the quality of life of anyone with mobility-hindering episodes issues can be affected. Some issues may arise due to different conditions like weather or the time spent standing, but when they do the client might feel underprepared if they do not have a mobility aid like a cane, wheelchair, or a seat. Mobility aids can be expensive or difficult to carry around when an episode does not occur, making it feel unnecessary to the client but are crucial in moments of intense fatigue, dizziness, or potential fainting.

Once completed, our device can be used instantaneously by taking it out of the client's bag/pocket and releasing the cane. The device will fully extend from its contracted state and give the person something to sit or lean on and use as support for standing. When extended, our device will also be able to contract back into its original state for ease of use and convenience. Our device aims to assist the individual physically through feeling safer traveling in open areas or walking short distances. Additionally, our device aims to mentally support the client by reducing the fear of not having a support system with them. Making the cane contractible to a small size allows for easy transportation, encouraging the client to bring it with them even if they do not experience symptoms very often, or cannot predict if they will be

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[4] Added by Jianna Bixho 5/13/25
[5] Edited by Caroline Walczak 5/22/25

experiencing symptoms that day. By using inexpensive materials, we will also be able to keep the price low to improve the accessibility of the device.

Purpose[6][7]

This document serves as a way to record the process of creating the prototype, the purposes of said prototype, and documenting all results from testing.

Summary of Market Research[8]

There were 3 major competitors to the team's design. The team began researching based upon common keywords for products within this field, such as “assistive balance” and “cane”, before narrowing down the returned results. As the end goal of this assistive device is to be available on the market for users to purchase, all researched competitors are devices that are currently being sold and used by customers.

The first competitor is a walking cane chair (Amazon, 2013). What was liked about the aspect of this design is that they put rubber ends to prevent slipping. The issue with the design is that it is unable to contract to a size that could fit in a backpack or pocket. The cane only contracts to the size of a walking stick, making transportation difficult. Also, the seat of the chair does not contract; instead, it sticks out on the side, which prevents the device from horizontally contracting.

[6] Written by Jianna Bixho5/22/25
[7] Edited by Caroline Walczak 5/22/25
[8] Written by Jianna Bixho 5/6-8/25
Edited by Anthea Sun 5/7/25

The second competitor is a height-adjustable cane (Amazon, 2023). What was liked about the aspect of this design is that the cane is able to contract to fit inside a backpack, which makes it easy to transport. However, the locking mechanism for this design is weak and cannot function properly if damaged. The locking mechanism consists of a series of silver buttons that are dependent on the one above it, meaning that if one button gets damaged, there is a high potential for the rest of the system to fail. Thus, the device can easily malfunction during use, posing a potential threat to the user.

The third competitor is a portable seat (Amazon, 2017). What was liked about the aspect of this design is that the seat contracts completely to a size smaller than a water bottle (<12”). However, the seat is heavily dependent on the active force the individual is able to exert onto it, meaning the user is required to consciously balance their weight to maintain equilibrium. This design is suboptimal for individuals with syncope, as if the user feels weak and unable to support themselves, they will fall and potentially cause harm.[9] In addition to the previously stated point, the material of the device is fully plastic, so it cannot support the full weight of a person without cracking. This weakness in material strength prevents the device from being used for a long period of time without the device becoming obsolete.[10]

Preliminary Designs[11]

The team initially designed three proof of concepts, beginning with B.U.N.J.E.E. (Figure 1). The design is a set of metal rods connected in series by a bungee cord. By

[9] Written by Anthea Sun 5/9/25
[10] Written and Edited by Jianna Bixho 5/9/25
[11] Added by Jianna Bixho 5/13/25

pulling the cord, the vertical tension force brings together the rods, forming the body of the cane. Between each rod is a 3D printed connector, chamfered to guide the following stage to align. A 3D-printed TPU stop sits at the end of the cane. The TPU stop increases friction with the ground, preventing slippage.

Figure 1: B.U.N.J.E.E. — Balance Utility Navigational Joints with Elastic Expansion

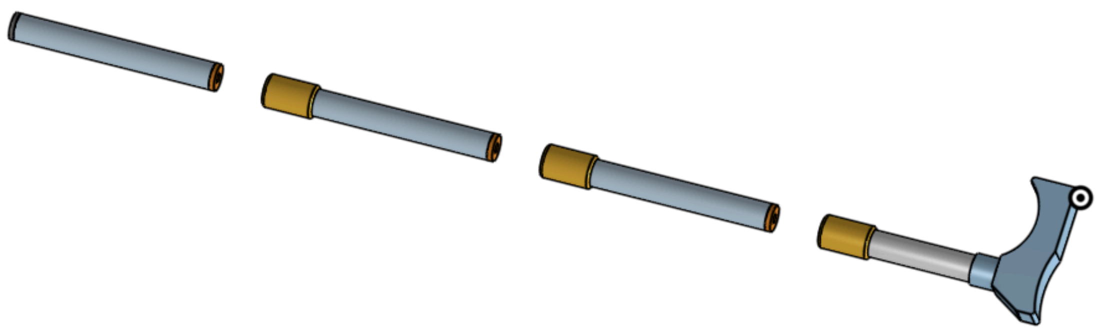

Figure 1: CAD of B.U.N.J.E.E. displays a A ¾ view of the tent pole design, segments separated. Yellow pieces indicate connectors within the design. This image does not show the connecting cord. Note that while this depiction shows vertical extrusion, the final design will have horizontal extrusion.

We then designed the other option of the Supportive Telescoping Extension Pole. The design follows that of a popular hiking stick design: a telescope. The telescopic cylinders are designed with a series of aluminium tubes of progressively smaller diameters nestled together (Figure 2). The tubes will lock together through a push into a channel and a magnetic seal.

Figure 2: S.T.E.P. — Supportive Telescoping Extension Pole

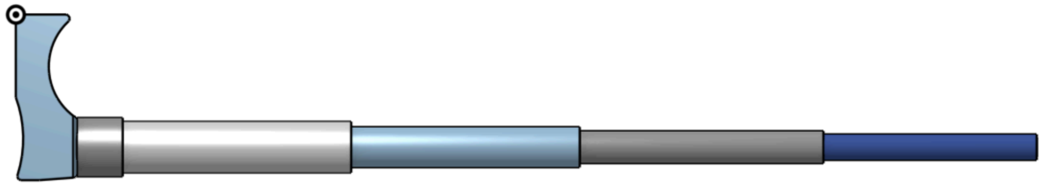

Figure 2: CAD of S.T.E.P. displays a side view of the telescopic design, segments extruded to length. The design consists of 4 (or more) parts vertically extruding downward.

The last design, the Cane Chair, emulates hiking chairs with its 3-legged collapsibility (Figure 3). The cane (blue) is able to fold outward to provide a seat for the client. The seat is made of fabric, allowing for further compression and carrying ease. Similarly to the other two designs, this seated cane's height can be modified to fit a range of heights.

Figure 3: Chair Design

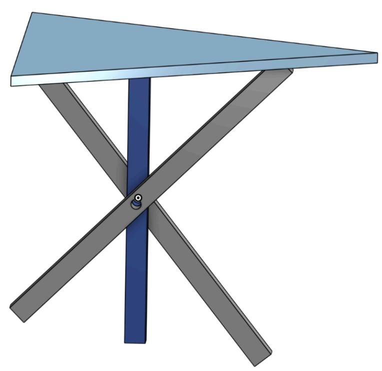

Figure 3: CAD of Chair Design displays the front view of the chair design. This design includes one hinge (center of the design) where the top section (fabric) collapses. The dark blue section incorporates a vertical extrusion, allowing this design the ability to provide support beyond sitting.

Building[12]

[12] Written by Anthea Sun 5/15/25

The final prototype was constructed by the CMO and CTO using the following steps. Previous prototypes were constructed in similar methods.

Materials

x4, 8”, 0.5” OD, 0.035” wall thickness

x1 Wooden Handle

x6 String Connector

x3 Outside Connector

x1 TPU Stop

x1 Bungee Cord

Super Glue

Step 1: Construction of aluminum body

For the aluminum body of the cane, 8-inch segments of the 1-inch outer diameter pipe were cut from longer 2-foot segments using a Miter saw equipped with a blade for cutting soft metals. The ends were then deburred (made smooth for safety) using files on the inside and outside of the pipes.

Step 2: 3D Printing Connectors

Connectors in and between aluminum segments were 3D printed in PLA, while the 3D printed stop for the bottom of the cane was printed in TPU for added friction with the ground. Printer used: Bambu X1C

Step 3: Carving the Handle

The handle was cut and shaped from a 3-inch by 5-inch by 1.5-inch piece of hardwood. The handle shape is a common ergonomic cane handle design. Using a belt sander, all edges were sanded smooth for added comfort.

Step 4: Assembly

3D printed parts were attached inside (string connectors) and around (outside connectors) the aluminum segments using super glue as a strong adhesive. In places where super glue was too thin to provide an adequate bond, hot glue was used to fill in gaps and provide stronger adhesion. Use the blade of a pair of scissors to fray one end of the bungee cord, then glue the frayed end to the wooden cane handle. The frayed bungee cord will assist in the bond between the two components due to the increase in surface area.

Step 5: Tensioning the Cord

The segments are connected by a bungee cord, which was tensioned to provide resistance while extended without being difficult to fold. The bungee cord was frayed at both ends, allowing better contact to the wood handle and TPU stop due to the increased surface area. After ensuring the super glue attaching the frayed end of the cord and the cane has dried, “thread” the cord through the completed components, with the handle being closer to the end without the string connector.

Step 5.1: If the Cord Needs Cutting

Thread cord through all segments. Then, pull on the cord until there is adequate tension. Pull harder on the cord for more tension, provide more slack on the cord to lessen tension. While keeping the cord manually tensioned, disconnect the two segments closest to the end of the cord from each other and fold them, mimicking the steps one would take to condense the cane. Making this movement while still proving manual tension will ensure the tensioning of the cord will not be so taught that the resulting cane is unable to condense. Find a tensioning that will allow all segments to condense. Then, cut the cord 1-inch above the location of your manual tensioning. After the cord has initially been cut, fine-tune the length to a final tension. As the cord is now shorter than the body of the cane and will spring into the body when not pulled, use a pair of needle nose pliers to stretch the cord again. After reaching the desired cord length, fray the end of the cord as in Step 4. Super glue the end of the frayed cord to the TPU stop. Allow the super glue to dry, then disengage the needle nose pliers from the cord. Due to the tension within the bungee cord, the cord should want to snap back inside the last segment. This tension should provide enough inward force that the TPU stop does not come out, however, the user can also super glue the TPU stop to the inside of the last segment if desired.

Additional: To add more segments

Cut 1*Amount of Added Segment(s) of 8-inch aluminium using the same procedure as Step 1. Print 1*Amount of Added Segment(s) of the string connector and 1*Amount of Added Segment(s) of the outside connector, using the same procedure as Step 2. Assemble the desired number of connectors as in Steps 4 and 4.1.

Step 6: Adding the locking mechanism

To add the lock that keeps the cane in its contracted form, use a wide strap and attach velcro to it. Hot glue one end to middle of the topmost aluminum segment and let the other hang freely. When contracted, wrap the strap around the chambers and secure it with the velcro.

Testing

[13]*Design Study 1: Functionality*

Purpose. This design study aimed to determine the average time our prototype would take to move from a condensed state to a lengthened state. The optimal device would be able to move rapidly with precision in order to best assist the client. Thus, the results from this test would allow us to determine if our prototype would be able to outperform current options on the market.

Dependent Variable. The dependent variable of this design study was the time taken in a full “cycle”: the time taken for the device to go from condensed to lengthened.

Independent Variable. The independent variable of this design study was the user testing the device. Keeping the user the same ensured user-induced idiosyncrasies would be the same as well.

Controlled Variables. The method by which the device was deployed was kept constant, as well as the user deploying it.

Materials. The Functionality test used Version 2 of B.U.N.J.E.E. and a mobile stopwatch.

[14]**Methodology.** 30 trials were held in which the user would deploy the device in a constant fashion. In each trial it was held approximately 20 degrees from the vertical and was then released. The length of time from release to the device being in it’s fully lengthened and stable form were recorded with the stopwatch.

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[13] Written by Anthea Sun 5/9/25, edited by Caroline Walczak 5/22/25
[14] Written by Caroline Walczak 5/22/25

Results. The B.U.N.J.E.E. prototype took an average of 3.19 seconds to go from its compressed to extended state, with a standard deviation of 1.581 seconds (Figure 4).

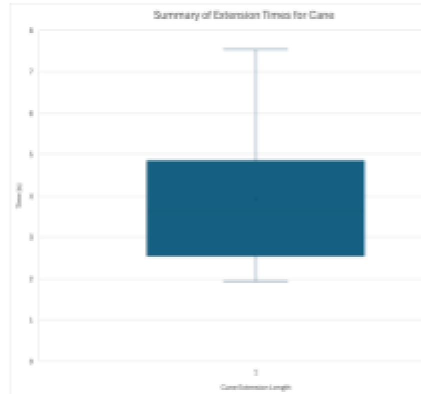

Figure 4: A Box-and-whisker plot of the recorded times it took to deploy the cane

Analysis. The functionality test revealed that the device deploys in a desirable amount of time, and with a p-value of 0, is significantly under the 30 second warning period often associated with conditions like vasovagal syncope (Cleveland Clinic, “Vasovagal Syncope: Symptoms, Causes & Treatment”).

Design Study 2: Durability[15]

Dependent Variable. The dependent variable of this design study was the durability of the device through force testing. The vertical max of force was not tested due to known properties of the materials used (6061 alumiunium, PLA, TPU), rather, the horizontal max of force was tested to account for partial horizontal forces acting on the object (in the event of usage on uneven terrain, cane not being perpendicular to the ground, etc.)

Independent Variable. The independent variable used in this design study is the weight applied to the device in its horizontal state. The weight was varied in 2.5 kilogram increments, until the device deformed.

Control. The method of which weight was introduced to the system was kept the same for each additional weight added.

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[15] Written by Anthea Sun 5/22/25

Constant. To avoid data discrepancies that could arise from testing canes of different lengths, the device length was kept consistent at all times.

[16]**Materials.** The Durability test used Version 2 of the B.U.N.J.E.E. prototype. 6 2.5 kilogram weights were used with a rope to hang from the cane.

Methodology. The cane was placed horizontally between two flat surfaces (see Figure 6) and weights were added successively until the plastic significantly deformed and it broke (see Figure 6). The degree of bend in the cane was measured from pictures taken using Tracker, a software for analyzing photos and videos mathematically.

Figure 5: Cane placed horizontally between two flat surfaces

Figure 6: Cane after putting 13.5 kg on it

Results.[17] The device was able to withstand 128.4N of force before deforming. The device buckled at a 3D printed connector where the weight consolidated, rather than the middle of an aluminium pole (Figure 7).

[16] Written by Caroline Walczak 5/22/25
[17] Written by Anthea Sun 5/22/25

Analysis. The horizontal force measured is the lateral force of the cane. From biometric studies, the average lateral force exerted on a cane during use is typically between 5.5% to 6.7% of the individual's total body weight (Chen et al., 2001), or approximately 40N-50N for a person weighing 70kg-80kg. Thus, the maximum lateral force of this device–128.4N–is approximately 3.2x-2.57x greater than the typical lateral force exerted on a cane. While this was decidedly sufficient due to the components of force cause by the angle at which the user puts their weight on the cane, to make the cane accessible to more individuals the use of stronger materials like nylon, molded plastic, or aluminum for the connectors would make it significantly stronger and able to support more weight.

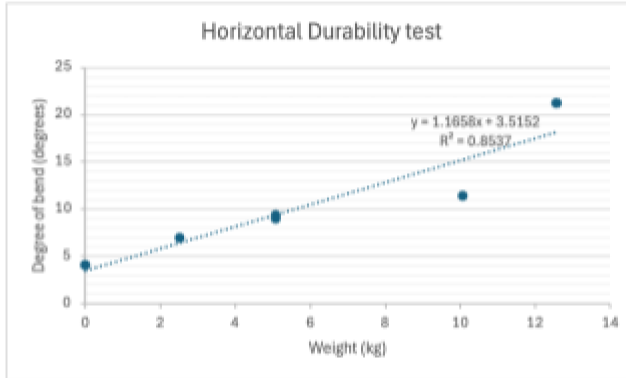


Figure 7: The mass of the horizontal force compared to the angle at which the cane is bent

Design Study 3: Usability

Purpose. To prioritize the safety and comfort of our clientele, this design study aimed to judge the device's handle with a quantitative value. The optimal device provides comfort and a feeling of stability to the client, opposed to a suboptimal device that actively causes the client pain.

[18]**Independent variable.** The individuals testing the handle, all having different hand sizes, varying in hand dominance, and varying in gender and age were the independent variables in the Usability test.

Dependent variable. The test subjects' comfort rating and reaction/feedback was the dependent variable.

Controlled variables. The handle for the B.U.N.J.E.E. prototypes was kept consistent across all trials. The users were asked the same question and given the same instructions on holding it.

Materials. The handle and methods of recording by writing ratings down was used.

Methods. 30 individuals were asked to hold the cane and put weight on it, and then rate it on a scale of 1 to 5, 1 being painful and 5 being comfortable.

Results. Overall, the majority of users, 33.33 percent, found the handle to be at a 4 on the 1 to 5 pain to comfort scale. The average rating was found to be 3.83 of. Other feedback was also received.

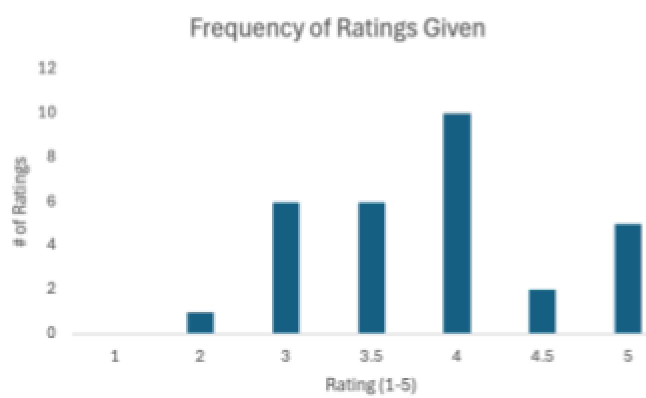


Figure 8: The frequency of individuals who rated the cane at a given rating

Analysis. With an assumed random sample and sample size of 30 people and hypothesizing that the

[18] Written By Caroline Walczak 5/22/25

mean rating is 4, statistical analysis revealed a non-statistically significant p-value of 0.2388. Feedback was given on future improvements, including adding finger grooves as well as being made out of a squishier material, which will be applied in future product iterations.

Prototypes[19]

Engineering matrices

Table 1: Engineering Matrix for three prototypes

				B.U.N.J.E.E. V1		B.U.N.J.E.E. V2		B.U.N.J.E.E. V3	
Level	Requirement	Type	Weight	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1	The design must be able to fully support the average weight of the average adult (80kg)	Physical	9	6	54	7	63	9	81
1	The device should have enough friction with the ground for the user to remain stable	Physical	8	9	72	0	0	9	72
1	The design must be able to contract/compress into a carryable item	Functionality	9	8	72	10	90	10	90
1	If deployed incorrectly, the device should prioritize user safety	Functionality	8	8	64	10	80	2	16
1	The user is able to distinguish a period of time prior to losing consciousness or falling	User	8	10	80	10	80	9	72
2	The design should stay compact until intentionally activated	Functionality	9	5	45	1	9	10	90
2	In its smallest stage, the device should take up less space than an average water bottle	Physical	8	7	56	9	72	5	40
2	The device should cost less than $40 (telescoping cane) or $90 (cane with foldable seat)	Cost	6	10	60	8	48	10	60
2	The device's handle should be ergonomic	Physical	6	0	0	8	48	10	60
2	the handle's design should not interfere with device usage	Physical	7	0	0	10	70	10	70
2	The device should be lighter than 2lbs	Physical	7	10	70	10	70	10	70
3	The device should include a user's manual to assist the client with its telescoping feature	Documentation	5	5	25	5	25	10	50
3	The device should include a user's manual to assist the client with adding or subtracting modules	Documentation	5	5	25	5	25	10	50
3	The height of the last stage can be modified to be shorter/taller	Functionality	6	2	12	0	0	10	60
3	The user has full mobility of at least one arm	User	5	10	50	10	50	10	50
			Total						
			1060		685		730		931

Table 1: The engineering matrix for three prototypes describes 15 requirements for the design, their type, their level/weight, and the weighted score of the design, revealing that B.U.N.J.E.E. V3, after the improvements made after V2 and V1, has a score of 931.

B.U.N.J.E.E. Version 1[20]

Figure 9: Initial Prototype

Figure 9: Initial prototype displays the first iteration of the B.U.N.J.E.E. cane

[19] Added by Jianna Bixho 5/22/25
[20] Written by Jianna Bixho 5/22/25

The initial prototype was created using PVC pipe, 3D printed parts, and a rope running along the center of the pipes. To extend the cane, the string needed to be pulled, and the 3D printed parts attached to the pipe segments would connect to each other when straightening. The release mechanism of the cane is inefficient because it takes lots of effort from the user to assemble, and requires two hands to deploy (one pulling the rope, the other holding the body of the device steady). The deployment was also inconsistent as the connectors would not always initially align with the PVC pipe. In addition, the cane does not have a handle for the user to hold, which makes it extremely uncomfortable to use.

B.U.N.J.E.E. Version 2[21][22]

Figure 10: Second Iteration

The second iteration of B.U.N.J.E.E. replaced the PVC pipe base with an aluminum-based body. A handle was made using wood and attached to the top of the cane. The CAD models were modified to fit aluminium, rather than PVC and 3D printed again. Instead of the manually-deployed string, a bungee cord was run through the center of the aluminum segments. One additional change made was a TPU stopper at the end of the cane to allow for more friction with the ground, preventing slippage. The TPU stopper also included a divot in the face that inserts into the cane–parallel to the handle–to provide a greater surface area for attaching

[21] Written by Jianna Bixho 5/22/25
[22] Edited by Anthea Sun 5/22/25

the tensioned bungee cord. However, the aluminum segments in this design would get caught on the sharp edge of the 3D printed parts and did not always fit into each other during expansion. This defect resulted in inconsistent activation. This version of the prototype was used for the three types of testing described above: Functionality, Durability, and Usability.

B.U.N.J.E.E. Version 3

Figure 11: Final Iteration

Figure 11: Final iteration displays the final version of B.U.N.J.E.E. cane

This design was improved by adding chamfers to the 3D printed parts to facilitate in expansion of the cane, as well as a velcro strap to wrap around the cane when fully contracted. The velcro strap is the retention mechanism of this design. The handle from the second iteration was used again in this design.

Final design summary[23]

Commit To The Byte presents B.U.N.J.E.E. (Figure 11), a cane for individuals that face situational walking-related mobility issues. The cane is lightweight, easy to transport, and supportive of the user's weight. This device is deployed quickly and simply, allowing the user that may be in a moment of panic to have a ready mobility aid in seconds with the simple pull of a strap.

The majority of our requirements (Table 2) were met, but our level 1 requirement of the device prioritizing user safety is not as significantly met as, if deployed at oneself or another person, they may be hit with the flinging motion of the device. Warnings regarding potential injury are in the safety manual, but future iterations of the design will attempt to make deployment safer.

The compression, light weight, activation, and hands-free aspects of the B.U.N.J.E.E. design all met the requirements, and even exceeded expectations.

Final requirements matrix

Table 2: Final Requirements Matrix

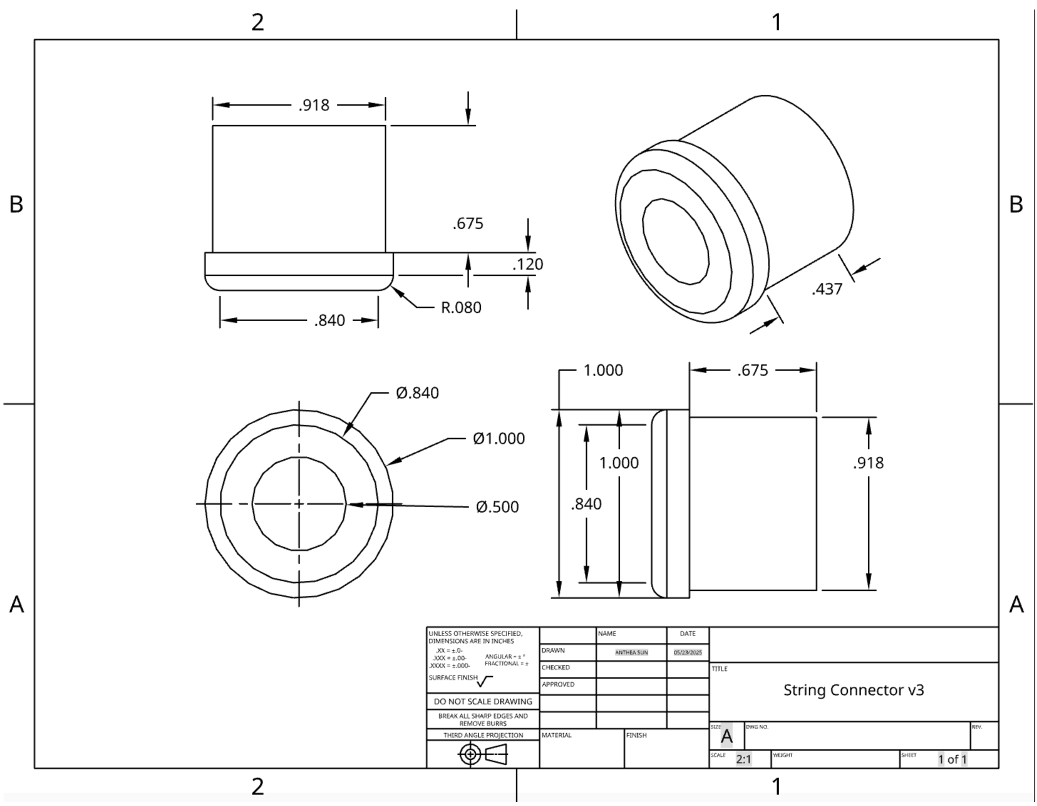
[23] Written by Caroline Walczak 5/22/25

Level	Requirement	Type	Weight	Score	Weighted Score
1	The design must be able to fully support the average weight of the average adult (80kg)	Physical	9	9	81
1	The device should have enough friction with the ground for the user to remain stable	Physical	8	9	72
1	The design must be able to contract/compress into a carryable item	Functionality	9	10	90
1	If deployed incorrectly, the device should prioritize user safety	Functionality	8	2	16
1	The user is able to distinguish a period of time prior to losing consciousness or falling	User	8	9	72
2	The design should stay compact until intentionally activated	Functionality	9	10	90
2	In its smallest stage, the device should take up less space than an average water bottle	Physical	8	5	40
2	The device should cost less than $40 (telescoping cane) or $90 (cane with foldable seat)	Cost	6	10	60
2	The device's handle should be ergonomic	Physical	6	10	60
2	the handle's design should not interfere with device usage	Physical	7	10	70
2	The device should be lighter than 2lbs	Physical	7	10	70
3	The device should include a user's manual to assist the client with its telescoping feature	Documentation	5	10	50
3	The device should include a user's manual to assist the client with adding or subtracting modules	Documentation	5	10	50
3	The height of the last stage can be modified to be shorter/taller	Functionality	6	10	60
3	The user has full mobility of at least one arm	User	5	10	50
			Total		
			1060		931

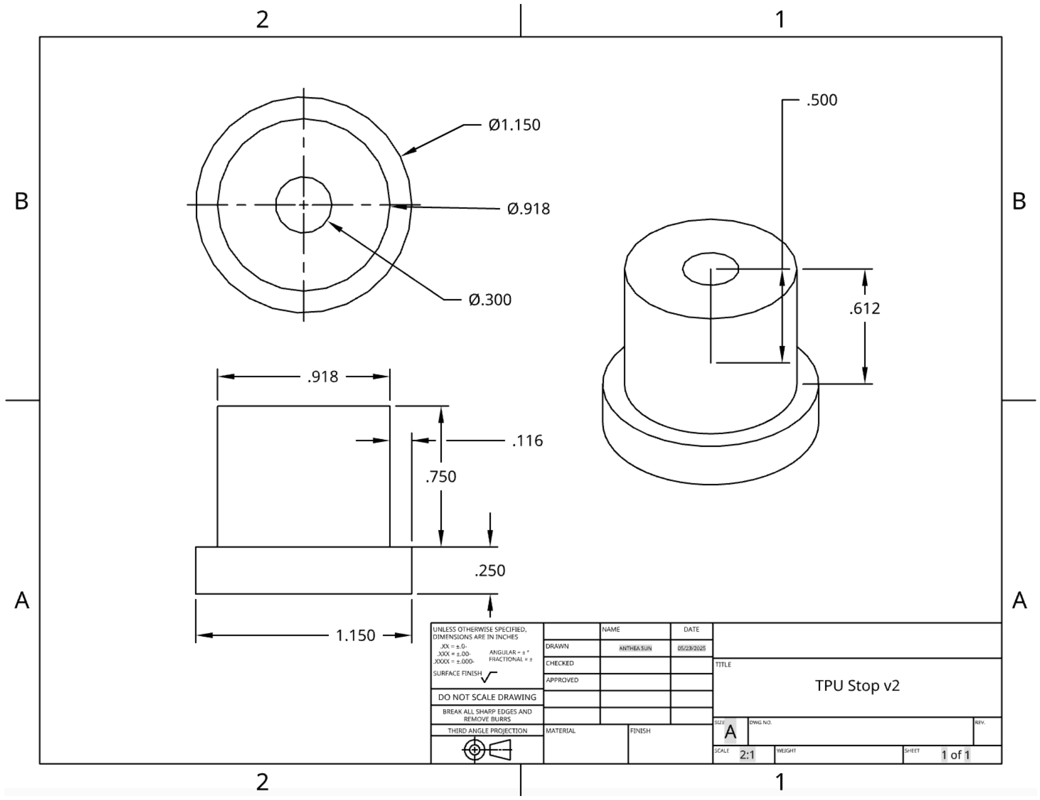
Table 2: Final Requirements Matrix is a scaled down version of table 1. It contains the requirements, but focuses solely on the score of the final prototype.

Dimensioned diagrams

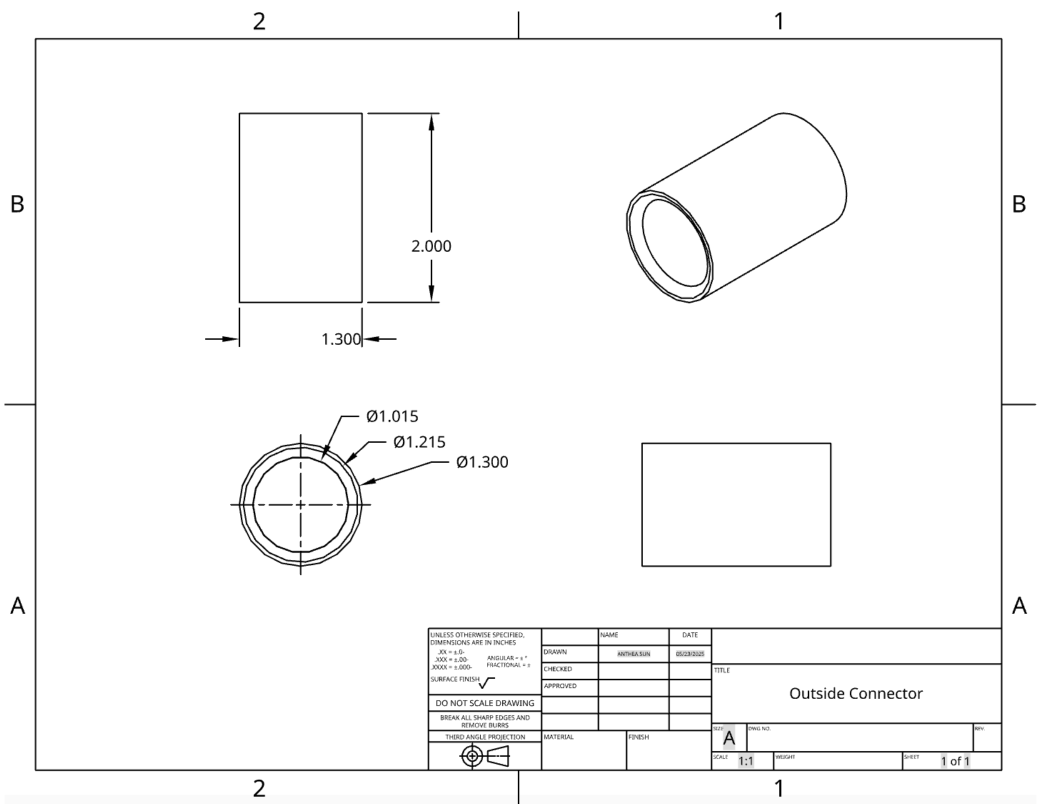
String Connector:



TPU Stop:



Outside Connector:



Future Steps

Commit to the Byte intends to improve Version 3 of the prototype by reinforcing the connectors with stronger material so it can sustain more weight. The handle will be improved upon by taking feedback from others about finger grooves and softer material, and the chamfers in the connectors may be adjusted so that deployment is more consistent and faster. The use of magnets will likely be beneficial as it may secure the cane in place with both the elasticity of the bungee cord and the magnetic force.

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Appendix: Bill of Materials and Tools

- Aluminum Pipe
  - 2 Ft
  - 0.5 in out diameter
  - $30.55
  - 3x
- Bungee Cord
  - ¼ in thickness
  - 10 feet in length
  - $5.55
- Soft wood
  - 3 in x 5 in x 1.5 in
- 3D filament
  - PLA
    - 1 kg
    - $10
  - TPU
    - 1 kg $10
- 10 in miter saw
- 10 in miter blade for metal cutting
- Metal file set
- Velcro straps (available supplies)