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Insulin Filling Station

Client: Michelle Somes-Booher, MBA
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Abstract

Problem: Lower income and Medicare insulin-dependent diabetic patients rely on syringes and vials for treatment. However, elderly and diabetics who have experienced complications often have difficulties lining up the syringe and vial. These difficulties frequently result in accidental pricks or bending of the needle, which leads to potential infection and replacement costs.

Purpose: In order to lower the injury and waste that elderly diabetes patients experience with syringes and vials, the device must ease the syringe filling process while remaining cost effective, affordable, and accessible.

Final Design: Two final designs have been fabricated. The Binder Design and the Drawer Design are alike in tensile strength, usability, and safety; they differ in sliding and locking mechanism.

Client Information

Michelle Somes-Booher is the Director of the Wisconsin Small Business Development Center at the University of Wisconsin - Madison. Her father designed a device to align the syringe and vial, which was a basis for the prototypes.

Motivation

- U.S. diabetes prevalence: one in ten Americans [1]
- Insulin Injections: requires fine motor skills, poses increased risks to elderly diabetic individuals.
- Solution: device that maintains stability, ensures sterility, and eases intake of the correct dose of insulin.

Background

- Target Population: low income elderly diabetic individuals
  - Diabetes complications: neuropathy, retinopathy
- Fine motor skills required for insulin filling process
  - Aligning needle and vial
- Risks of insulin injection
  - Insulin waste; needle bends, breaks, and pricks
  - Financial loss from needle and insulin waste; increased risk of infection

Competing Devices

Count-a-dose [2]:

Figure 1: The Prodigy Count-a-dose

Pros	Cons
• Accommodates lower visual dexterity users • Accurate filling • Compatible syringe/vial sizes	• Expensive (~50 $) [2] • Not ergonomic • Bulky

The Insul-eze [3]:

Figure 2: The Insul-eze

Pros	Cons
• Portable • Affordable • Magnifying	• Only accommodates certain sizes • Needs velcro/magnets to stabilize syringe/needle

Design Criteria

- **Safety:** Reduce adverse events
- **Ease of Use:** Intuitive use, limited fine motor skills
- **Manufacturing:** Injection molded for <$3.00 per device
- **Adaptability:** Accommodate vial and syringe sizes
- **Durability:** Withstand daily wear-and-tear (Testing Results)
- **Feasibility:** Three month period and $500 budget
- **Marketability:** Personalize exterior of device

Final Designs

Binder Design (Fig. 3): Locks when syringe side rotates shut such that clips slide into holes; enhanced viewing window.

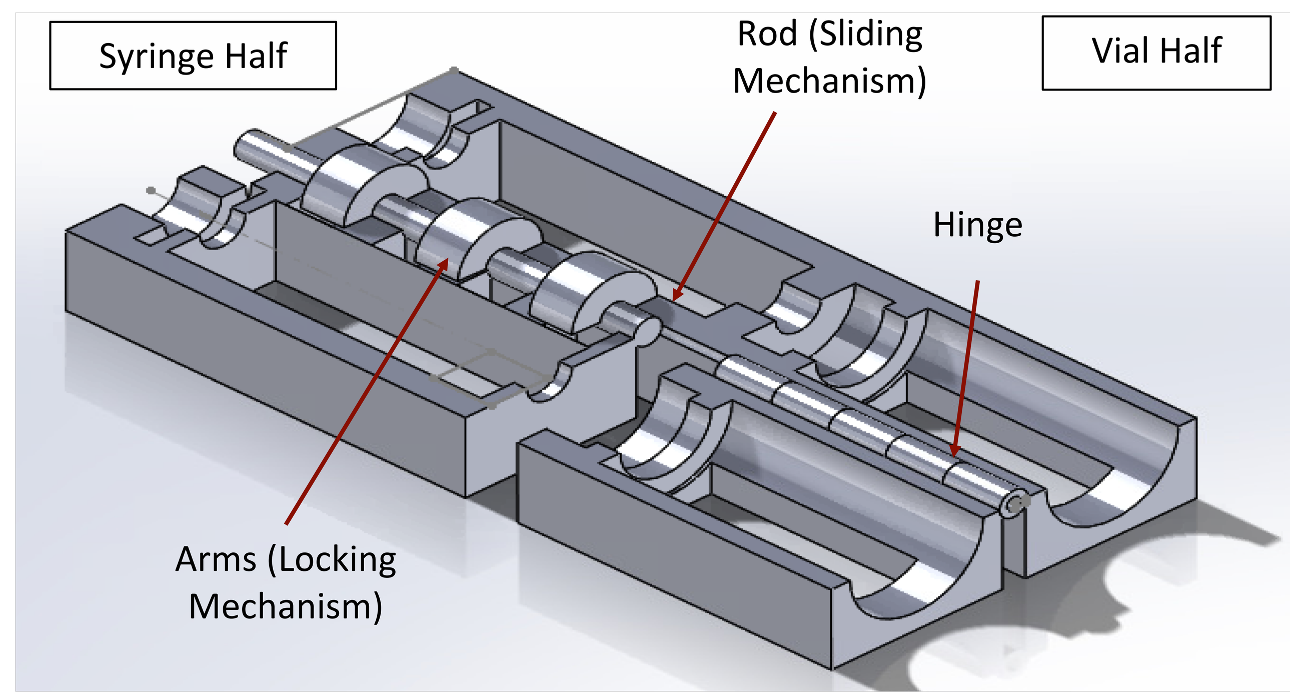

Figure 3: Binder Design CAD

Drawer Design (Fig. 4): Locks via gravity along the sliding track; features flexibility for length of syringe needle and amount of insulin.

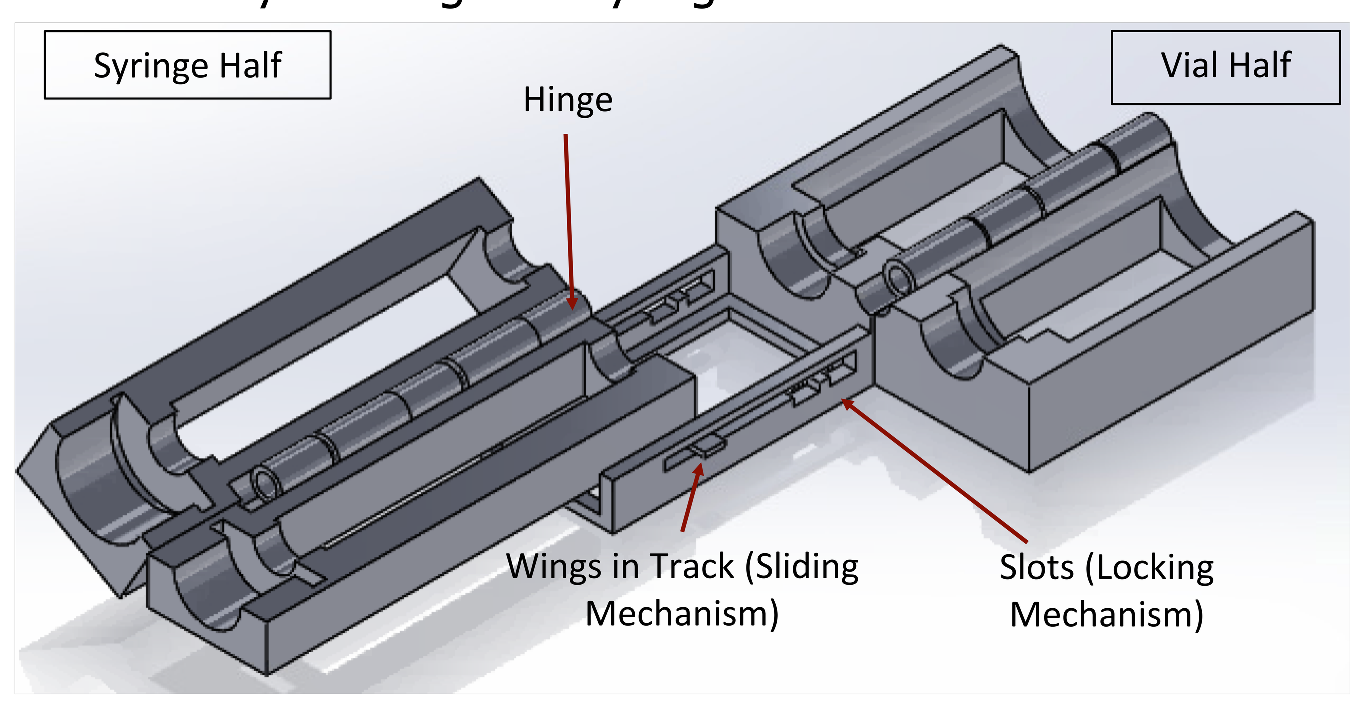

Figure 4: Drawer Design CAD

Design Criteria Met:

- Reduced risk of needle slippage, bending, breaking, poke
- Relies gross motor movements
- Withstand daily wear and tear
- Can customize exterior for advertising

User Manual:

- Step-by-step explanation with photos

Prototype Fabrication

Ultimaker (Tough PLA)
- Preliminary prototyping
- Low accuracy, low cost
- Prototypes used for:
  -Usability Testing
  -Visibility Testing
  -Design dimensions

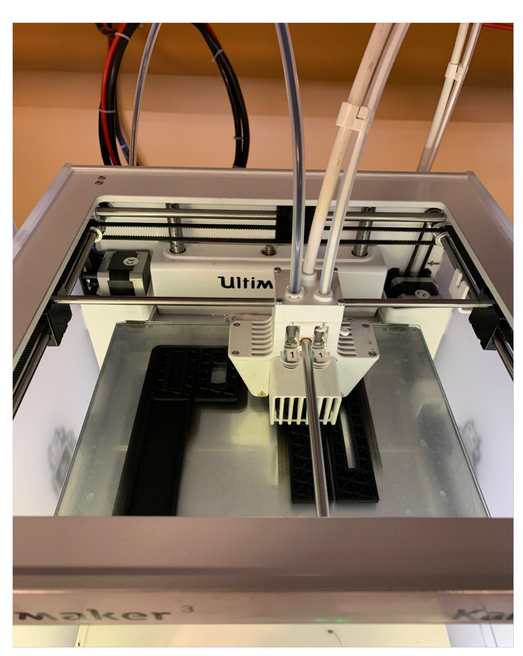

Figure 5: Prototyping sliding mechanism with Tough PLA

Stratasys (ABS)
- Final prototyping
- High accuracy, expensive
- Prototypes used for:
  -MTS testing
  -Final Design Determination

Figure 6: Loading Stratasys with final prototypes

Vapor Smoothing
- Gaseous acetone dissolves surface layer lines [4]
- Layers reform after acetone removed [4]
- Professional, smooth exterior

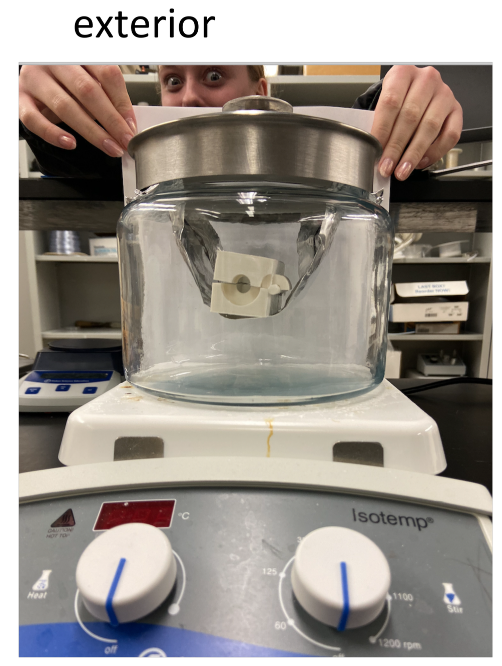

Figure 7: Vapor smoothing the final prototype

Testing

Visibility Testing: Visibility of syringe measurement markings
- Single window, double window, and reflective paint tested (Fig. 9)

MTS Testing:
- Characterization of axial forces involved with syringe-filling process
- Tensile axial loading testing for both final prototypes (Fig. 8)
  - Safety factor of 2

Figure 8: Testing final prototypes in MTS machine

Results

Visibility Testing: Double window: most visible for user and feasible for manufacturing (Fig. 9)

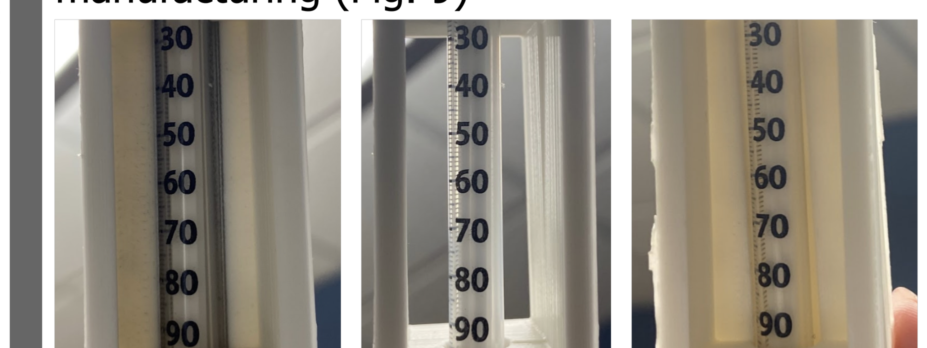

Figure 9: Three testing conditions for visibility testing. Left to right: Reflective Background, Double Window, Single Window

MTS Testing:
- Characterized axial forces involved in filling syringe
- Both locking designs withstood threshold axial forces (Fig. 10)
- Syringe Filling Force (Axial): 5.29 N
  - Averaged over five trials
- Device Requirement:
  - Maximum Force with FS = 2: 10.58 N

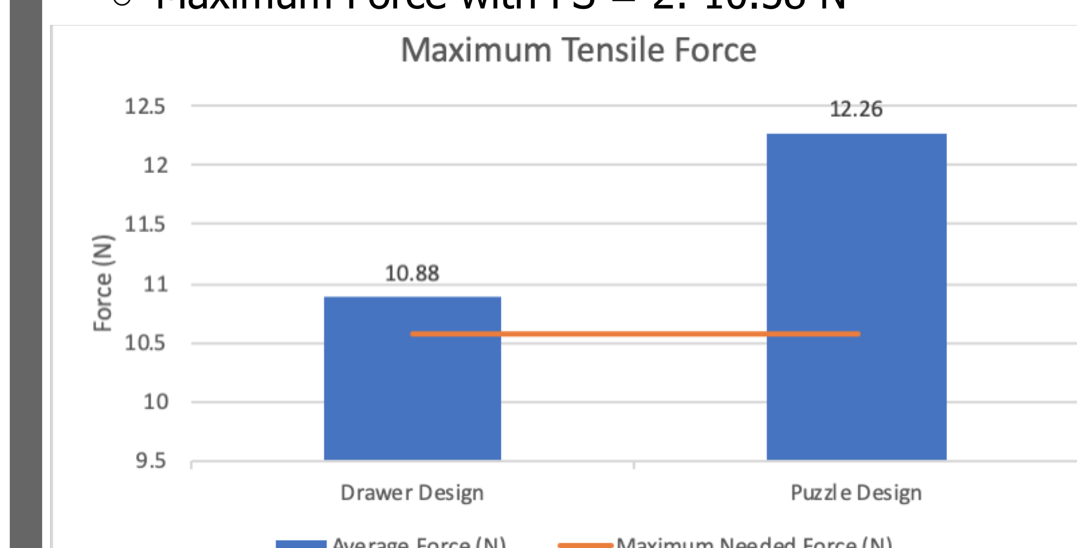

Figure 10: MTS testing results for each prototype averaged over three trials

Final Design

Final Design: Binder Design
- Greater stability of syringe and vial halves once locked together
- Less small, fragile components that may break
- More stability on sliding track
- Injection molding feasibility

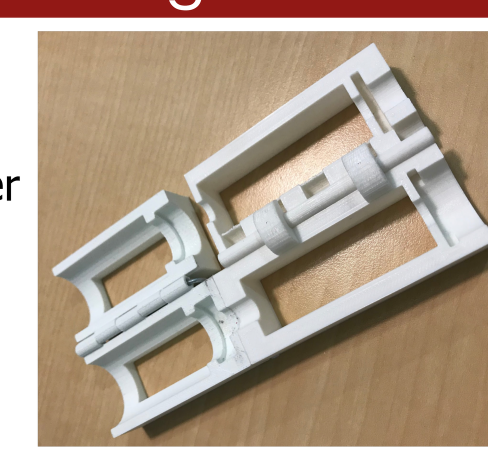

Figure 11: Final Design: Binder Design

Future Work

- Collaborate with ProtoLabs; make design changes and improve injection molding feasibility
- Increase cost-effectiveness: material choices, design changes
- Usability and force testing with different brands of vials and syringes

Acknowledgements

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References

[1] "Type 2 Diabetes | Basics | Diabetes | CDC," https://www.cdc.gov/diabetes/basics/type2.html.
[2] Prodigy Diabetes Care. (2019). *Prodigy Count-a-Dose® Insulin Syringes | Prodigy Diabetes Care*. [online] Available at: http://www.prodigymeter.com/consumers/diabetic-supplies/prodigy-count-a-dose-insulin-syringe/ [Accessed 28 Sep. 2019].
[3] Ambi Med Inc. (2019). *Insul-eze Syringe Magnifier magnifies 2x for easy viewing*. [online] Available at: https://www.ambimedinc.com/insul-eze/ [Accessed 28 Sep. 2019].
[4] H. Gao, D. V. Kaweesa, J. Moore, and N. A. Meisel, "Investigating the Impact of Acetone Vapor Smoothing on the Strength and Elongation of Printed ABS Parts," Jom, vol. 69, no. 3, pp. 580–585, Dec. 2016.