

Design Technology SL Internal Assessment: Designing a Product to Reduce E-Waste



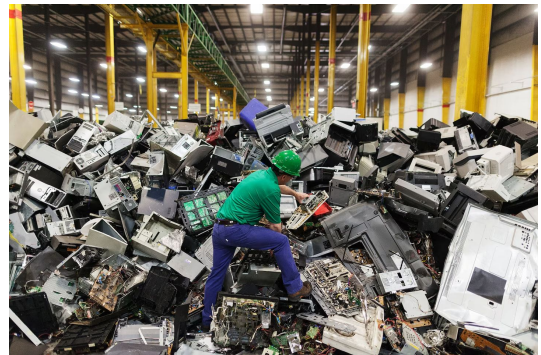
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A2	95
A3	682
B1	93
B2	81
B3	143
C1	215
C2	No extended writing
C3	55
D1	364
D2	142
D3	163

The Problem:

In many elementary schools, outdated technology persists, with iPads equipped with first-generation Apple Pens still in use. These pens lack convenient/stable attachments to the iPads, making them prone to getting lost easily, especially among young children who may misplace or forget them, leading to electronic waste. Additionally, the fine motor skills of children is a consideration, because most children may not develop strength and dexterity that allows them to perform everyday tasks by age 7-8 (understood.org).

The Director of I.T. for a school has provided data about the year 2023-2024 for elementary school:
- Over 400 electronic devices in total and 8 Electronic peripherals damaged, lost or broken.
They have also said that “resources are needed to request and order new equipment. We want to reduce the burden on support teams and allow them to focus on more strategic initiatives”, indicating how inconveniences due to complications with small electronic peripherals take time from important tasks. Additionally they have told me that our school uses a specific case for its ipad, and that any designs must fit this case.

Exposure to e-waste has been linked to a range of negative health outcomes such as birth defects, harm to both the central and peripheral nervous systems, distortions in blood composition and damage to vital organs such as the lungs, liver, and kidneys.



- 50 million tons of waste per year
- 7 % - Small electronic devices and peripherals
- Toxic chemicals including: Lead, Cadmium, Dioxins, Furans, Arsenic, Mercury, DDT, PCB, Chromium, Vinyl chloride, Antimony, Beryllium

Problem Justification



Can be easily lost because case not equipped with mount

Large fingers limit precision finger movements

Ages 8 and younger possess noticeably lower dexterity

Large shapes and figures for ease of use



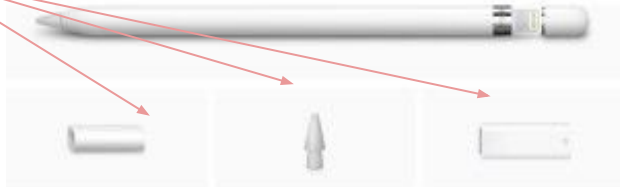
Safety considerations for young children -

- Flame Retardant Materials
- Secure Fastenings
- Avoiding Pinch Points
- Free from any sharp edges or small parts
- Choking hazards
- Materials used should be non-toxic

Numerous small attachments which can get lost

Does not have any connection method to Ipad

Constructed out of hazardous materials



The product must:

- Be lightweight and portable
- Be safe for use by children
- Minimize the chance of electronic waste

Relevant Parameters:

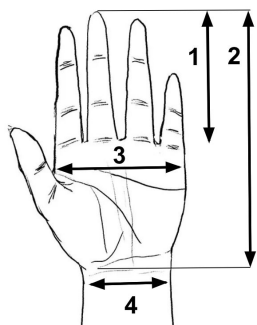


Figure 1 - Labeled Hand (shop.zenartsupplies.co)

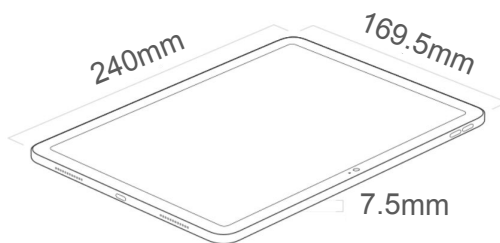


Figure 3 - Apple Ipad 6th Generation Dimensions (maccity.com)

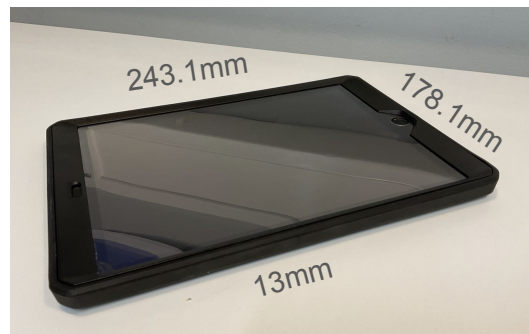


Figure 4 - Moko Ipad Case used at school (amazon.com)



Figure 2 - Apple Pen 1st Generation Dimensions (amazon.com)



Anthropometric Data for Boys and Girls Hands Aged 5 to 11.4 Years (see Figure 1)								
Age (years)	Left Hand				Right Hand			
	All physiological hand measurements in centimeters (cm)							
	1. Full Length	2. Middle Finger Length	3. Width	4. Wrist thickness	1. Full Length	2. Middle Finger Length	3. Width	4. Wrist thickness
5-5.4	12.72	5.4	5.85	2.60	12.72	5.40	5.85	2.60
11.11.4	17.11	7.33	7.91	3.54	17.11	7.33	7.91	3.54
Age (years)	Left Hand				Right Hand			
	Grip and pinch strength in pounds (lbs)							
	Grip Strength	Palmar Pinch Strength	Lateral Pinch Strength	Tip pinch strength	Grip strength	Palmar pinch strength	Lateral pinch strength	Tip pinch strength
5-5.4	28.4	4.8	3.6	4.4	30.4	5.0	3.9	5.4
11.11.4	49.6	8.4	10.2	7.8	52.1	10.5	10.4	9.8

source: pmc.ncbi.nlm.nih.gov


Design Brief:

Will design and manufacture a one-off working prototype for limiting the waste of Apple Gen-1 in schools. This product will also take into consideration ergonomics and the fine motor limitations of young children. Target audience is elementary school aged children which are typically between the ages of 5 and 11 years old. Expected outcome is that this product will prevent/significantly mitigate the chances of creating waste associated with apple pens. The prototype should be simple, lightweight and conform to the safety requirements for children, so it could be implemented in schools around the world.

Design Specifications

Numbers before categories are in correspondence with importance, i.e. category x (name) is most important and category y (name) is least important.
 - Put here if categories weight the same in importance

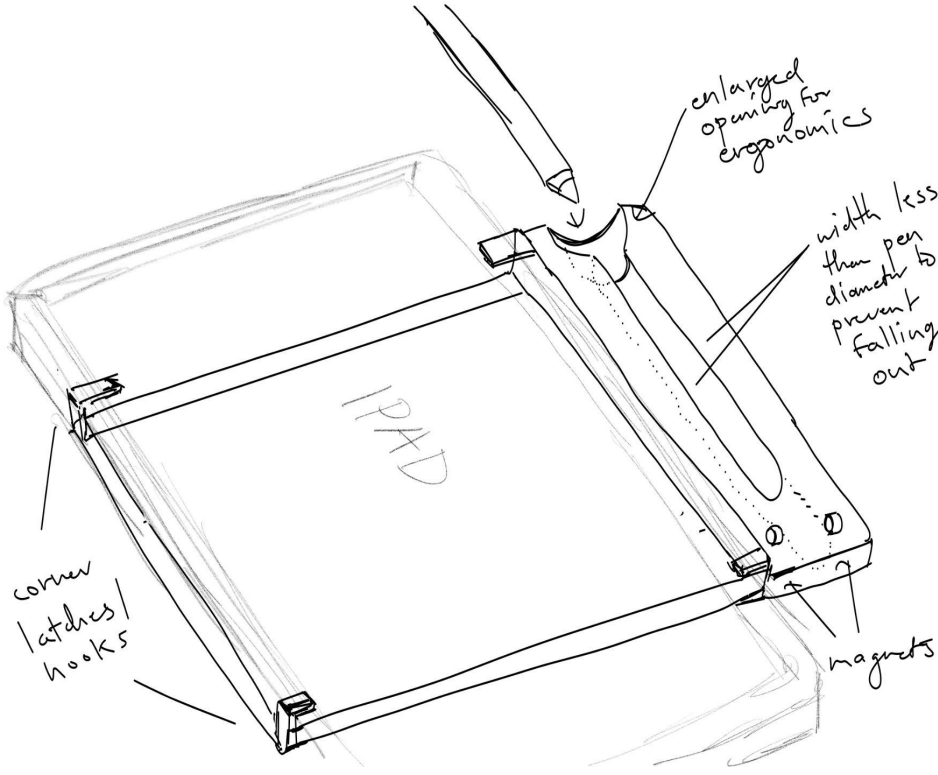
Area	Specification	Justification	Testing Strategy
<p>1. Function</p>	<p>1.1 Will minimize the chance of electronic waste (loss of apple pens)</p> <p>1.2 Must stay in tact after 20 drops from 1.5 m height</p> <p>1.3 Strong attachment to ipad (3N to separate apple pen)</p> <p>1.4 Safe for young children to use</p> <p>1.4a All edges must be rounded</p> <p>1.4b Can be no air gaps which can pinch</p> <p>1.4c Can't have small parts less than 5x5x5 centimeters</p>	<p>1.1 - Each year, 50 million tons of waste are generated, with small electronic devices and peripherals accounting for 7% of this total. This electronic waste contains toxic chemicals such as lead, cadmium, dioxins, furans, arsenic, mercury, DDT, PCB, chromium, vinyl chloride, antimony, and beryllium. Cost per apple pen lost is approximately 120 euros (apple.com).</p> <p>1.2 - Research indicates that children aged 5 to 11 experience significant changes in motor skills and strength development, which can result in a higher likelihood of dropping things. Therefore the product must be protective and rigid. (sources: verywellfamily.com, canada.ca, northshore.org)</p> <p>1.3 - Product should be safely fastened to the device so that children will be unable to separate it and lose it. Adults in school should be available for assistance in attaching the product.</p> <p>1.4a - No sharp edges due to an increase in the risk of accidental cuts or injuries.</p> <p>1.4b - Should be designed without pinch points to prevent accidental trapping of fingers or skin.</p> <p>1.4c - Small parts can pose a choking hazard if accidentally ingested. Each year in the U.S, a child dies every 5 days and over 12,000 children end up in the ER. (sources: health.ny.gov, kidshealth.org)</p>	<p>- Testing/trials</p> <p>- Surveys and interviews with users</p>

<p>2. Aesthetics</p>	<p>2.1 Should come in pastel blue or green colors</p> <p>2.2 Sleek and simplistic design</p>	 <p>Classic Silver Sage Color Scheme - by SchemeColor.com</p> <p>pinterest.com</p> <p>The added color allows teachers to see whether students have it on their ipad as ipads usually come in silver or dark grey.</p> <p>According to a study done by (frontiersin.org) these colors promote calmness and focus which are beneficial in a classroom environment.</p> <p>These colors are also environmentally friendly as they are not overly intrusive in nature if students conduct field trips outside of school.</p> <p>2.2 Simplistic design will prevent as many distractions as possible. Young children often struggle with staying concentrated and this product should not further induce distractions.</p>	<p>- Survey sent to potential or actual users</p> <p>- Visual check</p>
<p>3. Target Audience</p>	<p>3.1 Will be used by young children aged 5 - 11.4 who are in primary/elementary school</p> <p>3.2 Designed for 5th percentile in the age range 5 - 11-4</p>	<p>3.1 Will be tailored to young children because they are more likely to lose small items.</p> <p>They are also more likely to receive electronics from their school because most students don't have expensive personal electronics till high school.</p> <p>3.2 All physical aspects will be designed for the lowest percentile so that everyone in the age group may use the object. For example with weight, the least strong individual in the age group should be able to comfortably use the product.</p>	<p>- Surveys with the actual and potential target Audience</p> <p>- Trials</p>

<p>4. Target Market</p>	<p>4.1 Intended for school environment</p> <p>4.2 Cheap to produce and buy</p> <p>4.3 Simple and quick setup process</p>	<p>4.1 Product is designed with a school environment in mind, i.e. consideration of environmental factors such as the importance the product not being a distraction to students.</p> <p>4.2 Designed for schools which don't have high amounts of funding to allocate</p> <p>4.3 Setup process must be easy for teachers to comprehend and quick to do given high number of potential installations required</p>	<p>-Surveys with students and teachers</p> <p>- Surveys with faculty to see if they would purchase it</p> <p>- Time the setup process</p>
<p>5. Material Selection (Properties/ characteristics)</p>	<p>5.1 Non - toxic materials</p> <p>5.2 High impact resistance and toughness</p>	<p>5.1 Non-toxic Materials which are safe for children to handle and sometimes even chew on is necessary for an elementary school environment.</p> <p>5.2 It needs to withstand drops and rough handling, making it ideal for young children who may drop the product often. (standard.co.uk)</p>	<p>- Interviews</p> <p>- Check that materials with these properties are being used</p> <p>- Drop and other durability testing</p>
<p>6. Size Constraints</p>	<p>6.1 It should be no larger than 260mm (length) x 190mm (width) x 20mm (height)</p> <p>6.2 Must weigh less than 250 g - Portable and lightweight</p>	<p>6.1 A 10th generation ipad has the dimensions 248.6mm (length), 179.5mm (width) and 7mm (height). Footprint should not extend more than 15 millimeters in any direction to maximize portability. Hand anthropometrics range from 127.2 mm - 171.1 mm which is sufficient to grip an object with a thickness of 15 mm.</p> <p>6.2 Children may move around often with the device in their hands or go on trips outside of school. This requires it to be convenient to carry, as well as not increase the weight of the ipad significantly which is 477 g.</p>	<p>- Visual check</p> <p>- Trial with the product to check the fit</p>
<p>7. Production Constraints</p>	<p>7.1 Manufactured with school equipment or from an outsourced workshop (local)</p>	<p>7.1 The available machines and equipment variety will enable the creation of a fully functional prototype. If the school's equipment is insufficient, Outsourcing will be utilized.</p>	<p>- Note down each machine used</p>
<p>8. Quantity</p>	<p>8.1 Will construct a one-off prototype</p>	<p>8.1 One product will be manufactured which has full function and is able for customer use</p>	<p>- Only one item is manufactured</p>

: Meets specification point

 : Does not meet specification point



- 1.4a rounded edges
- 1.1 will minimize chance of losing pen
- 1.4b may have pinch points

2.2 Sleek and simplistic design

6.1 Should be no larger than 260mm (length) x 190mm (width) x 20mm (height)

6.2 Must weigh less than 250 g - Portable and lightweight

5.2 High impact resistance and toughness

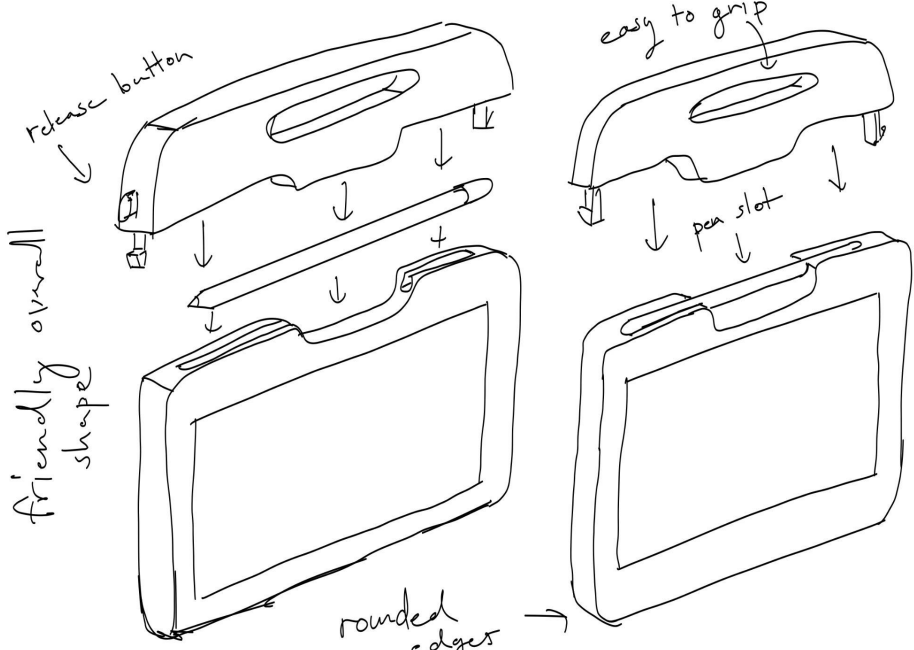
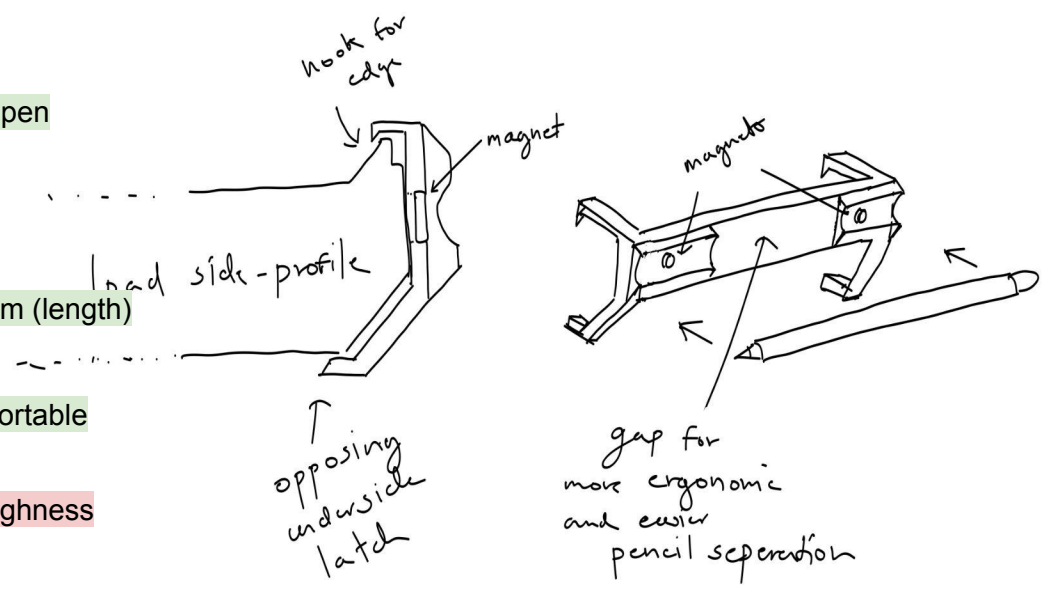
- 1.4a not rounded edges
- 1.1 will minimize chance of losing pen
- 1.4b no have pinch points

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5.2 High impact resistance and toughness



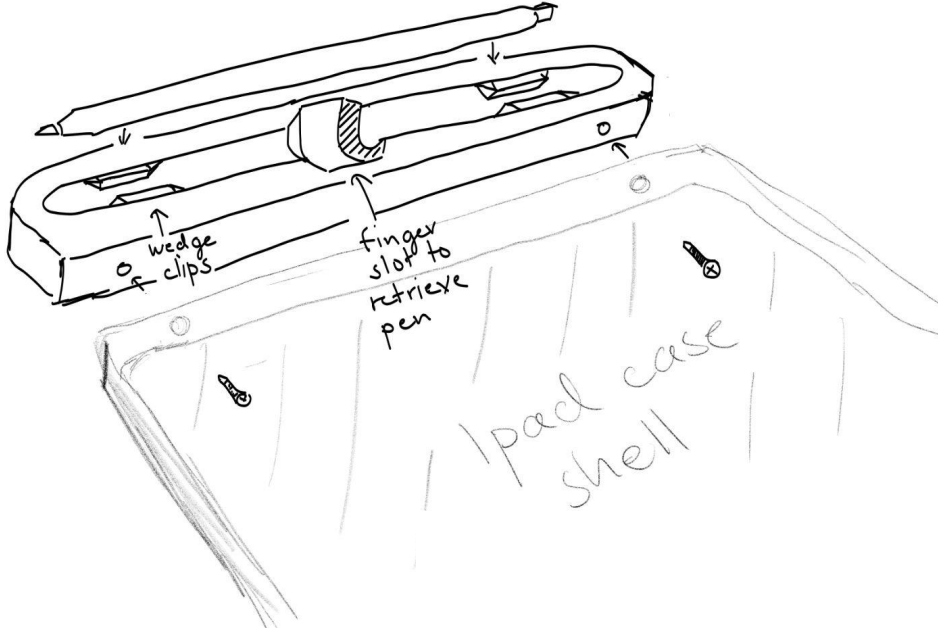
- 1.4a rounded edges
- 1.1 will minimize chance of losing pen
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5.2 High impact resistance and toughness

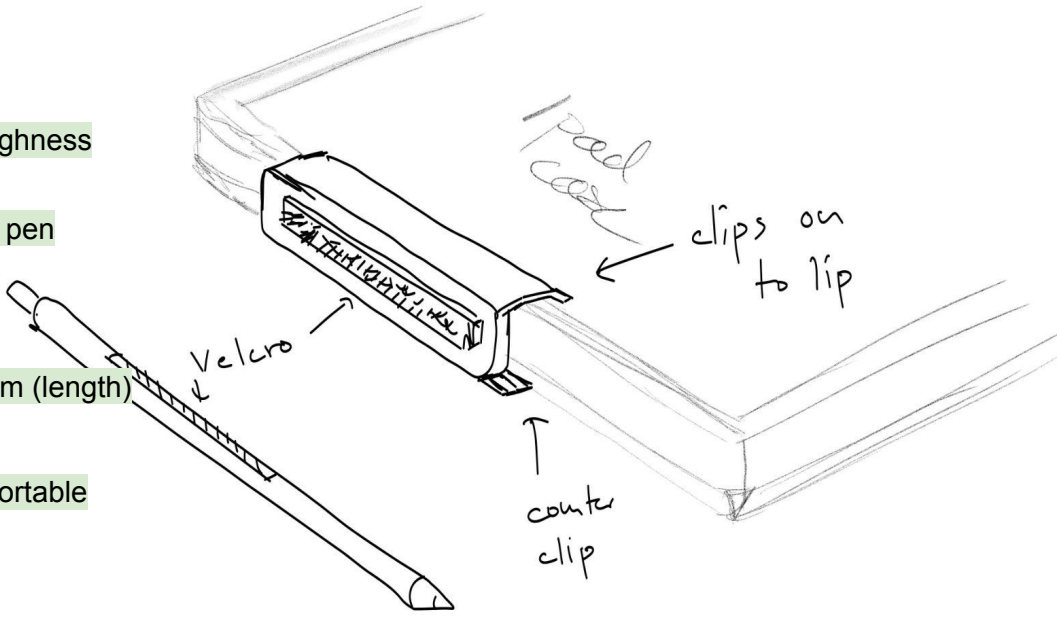
- 1.4a rounded edges
- 1.1 will minimize chance of losing pen

- 1.4b may have pinch points

2.2 Sleek and simplistic design

6.1 Should be no larger than 260mm (length) x 190mm (width) x 20mm (height)

6.2 Must weigh less than 250 g - Portable and lightweight



ipad case

will latch onto upper ledge of case

coiled spring loaded wire to keep pen attached

- 1.4a rounded edges

- 1.1 will minimize chance of losing pen

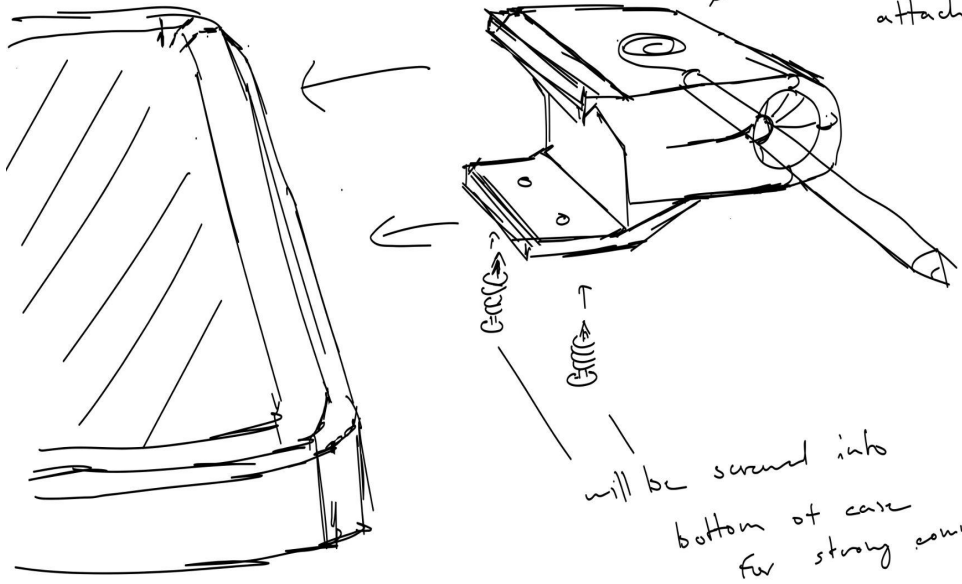
- 1.4b no have pinch points

5.2 High impact resistance and toughness

6.1 Should be no larger than 260mm (length) x 190mm (width) x 20mm (height)

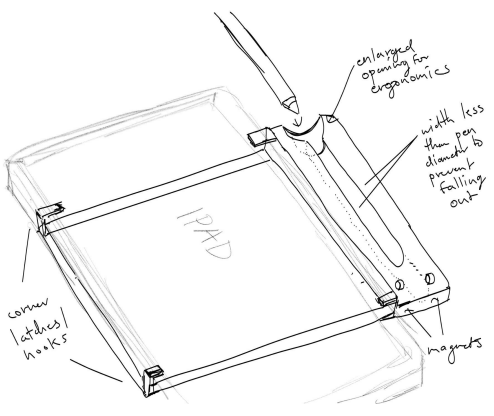
6.2 Must weigh less than 250 g - Portable and lightweight

2.2 Sleek and simplistic design



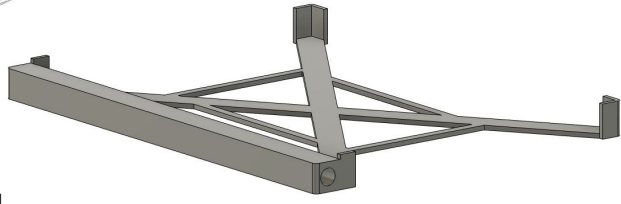
	Design					
Specification	1	2	3	4	5	6
1. Function		1.4a not rounded edges	1.4b may have pinch points	1.4b may have pinch points	1.1 will minimize chance of losing pen - 1.4b may have pinch points	
2. Aesthetics	2.2 Sleek and simplistic design		2.2 Sleek and simplistic design	2.2 Sleek and simplistic design		2.2 Sleek and simplistic design
3. Target Audience						
4. Target Market						
5. Material Selection (Properties/ characteristics)	5.2 High impact resistance and toughness	5.2 High impact resistance and toughness			5.2 High impact resistance and toughness	
6. Size Constraints			6.1 Should be no larger than 260mm (length) x 190mm (width) x 20mm (height) 6.2 Must weigh less than 250 g - Portable and lightweight			
7. Production Constraints						
8. Quantity						
Score	13/16	13/16	8/16	12/16	10/16	14/16

Concept

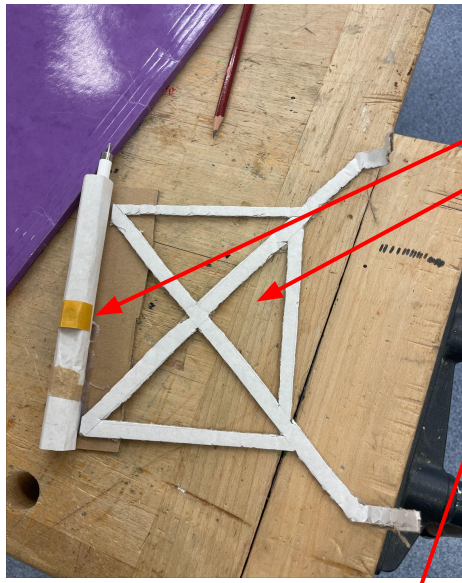


Design 1 Development

Conceptual CAD model



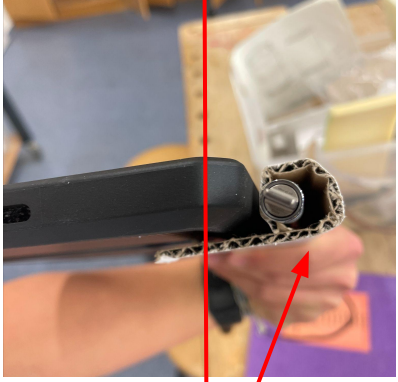
Initial card modeling



Magnet taped on for testing of thickness and magnetic effect

Backside structure will keep pen fixed to ipad

- Backside structure covers backstand of case



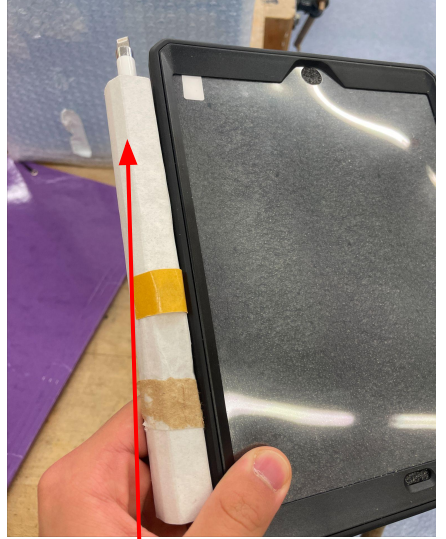
Specification	Design 1
1. Function	
2. Aesthetics	2.2 Design is complex with a seemingly flimsy attachment to tablet
3. Target Audience	
4. Target Market	
5. Material Selection (Properties/ characteristics)	5.2 Not a good structural design for staying on the ipad
6. Size Constraints	6.1 Width may exceed 190 cm
7. Production Constraints	
8. Quantity	
Score	11/16

Client Feedback

“Is very large, doesn't look structurally stable, will prevent the stand from deploying, not visually pleasing”

- Card too thick for single magnet

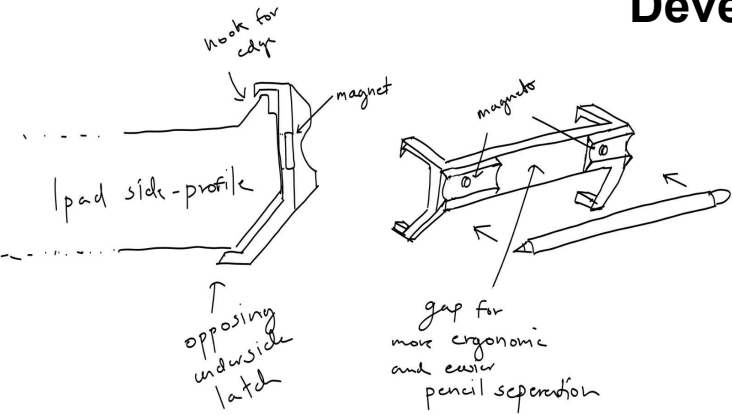
+ More protection for the pen



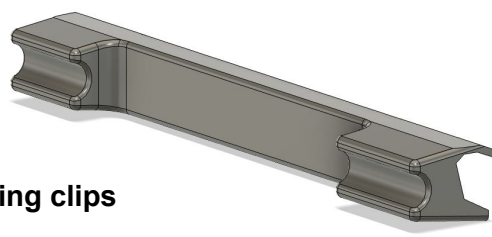
- Pen easily slips out

Concept

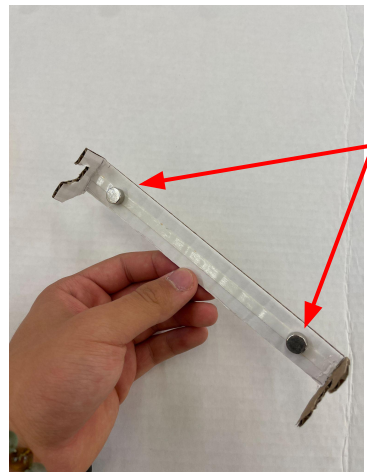
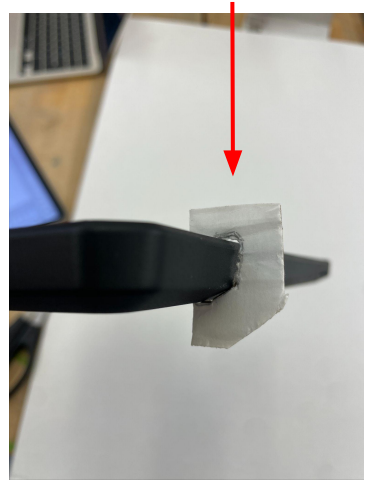
Design 2 Development



Conceptual CAD model



- cross sectional fitting clips work with reasonable strength even with cardboard

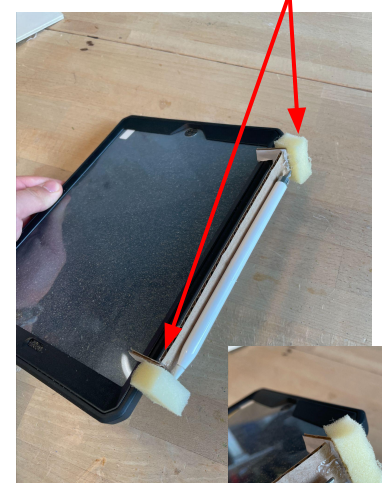
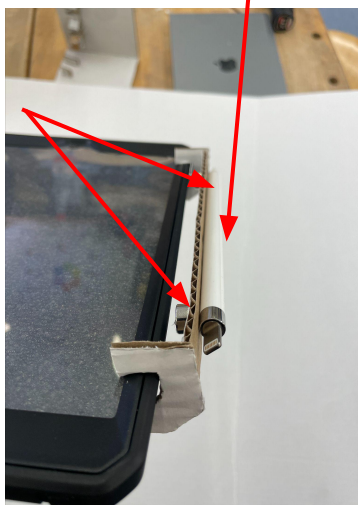


Magnets taped to back side of pen holder using double sided tape

Potential issue with magnets - only two places where pen is magnetic

+ Magnets are more than strong enough to hold pen

+ Foam pieces glued proves pen can stay attached after fall



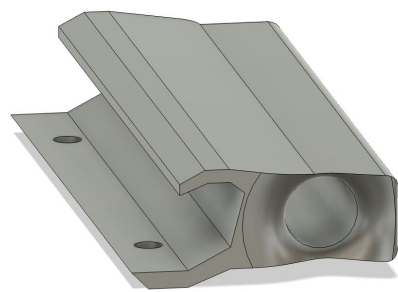
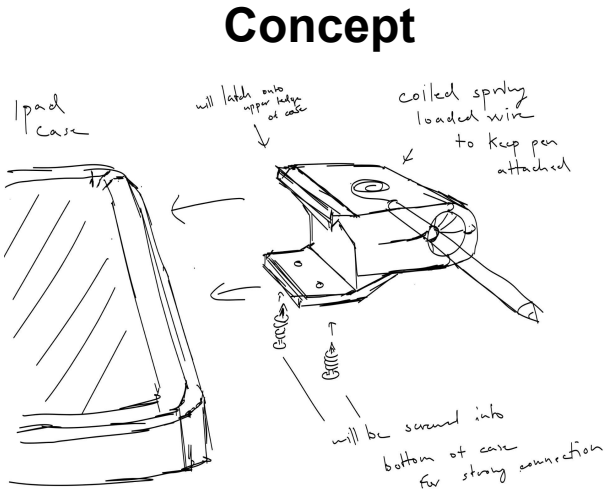
Client Feedback

“Too flimsy, looks like it would break off, Inconvenient ergonomics with the flat wall against the pen”

Specification	Design 2
1. Function	1.4a corners of the initial card modeling are too pointy
2. Aesthetics	
3. Target Audience	
4. Target Market	
5. Material Selection (Properties/ characteristics)	5.2 Conceptual card model breaks/falls off very easily
6. Size Constraints	
7. Production Constraints	
8. Quantity	
Score	13/16

Design 3 Development

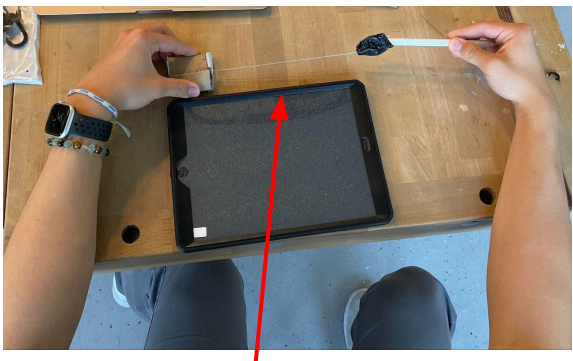
Conceptual CAD model



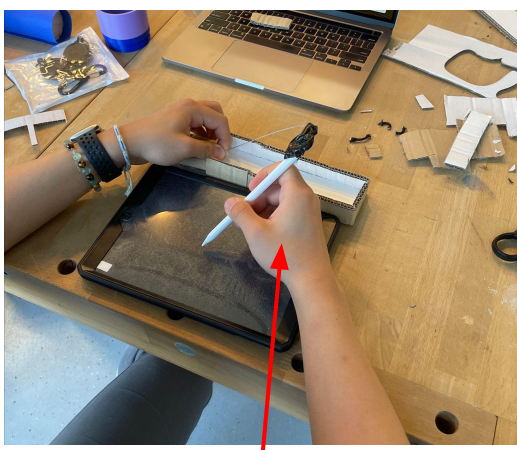
Retractable wire inside cardboard box attached to end of pen



Testing a box or place to store pen when not in use



+ Better security of pen as it is attached with retractable wire



+ Easy for students to pull string and use pen on screen while attached

Client Feedback

“Too hard to pull string out, must have locking system so you don’t have to hold it the whole time, retraction is too strong”

Specification	Design 6
1. Function	
2. Aesthetics	2.2 Product is too bulky and somewhat over designed and simplistic
3. Target Audience	
4. Target Market	
5. Material Selection (Properties/ characteristic)	
6. Size Constraints	6.2 Can be quite heavy with retractable cable system
7. Production Constraints	
8. Quantity	
Score	12/16

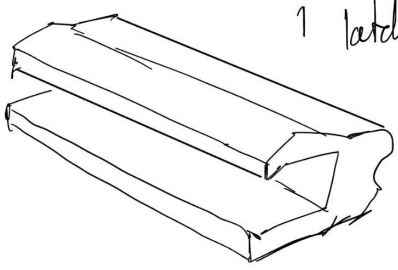
- + Container fits pen safely
- Not a snug and secure fit



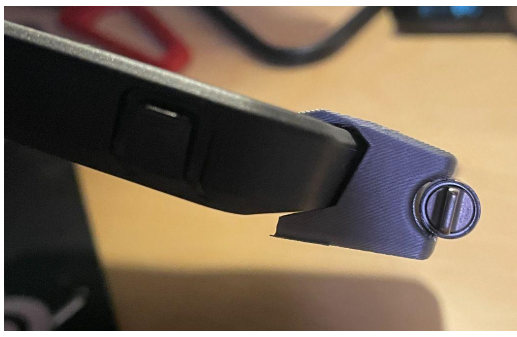
Focused design

Durability and Attachment to Ipad

1st idea "Latch on"



1 latch on



- + Is flush will side profile of ipad (no pinch points)
- + Has enough friction to the point of not sliding

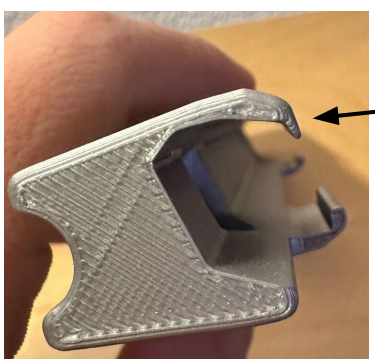
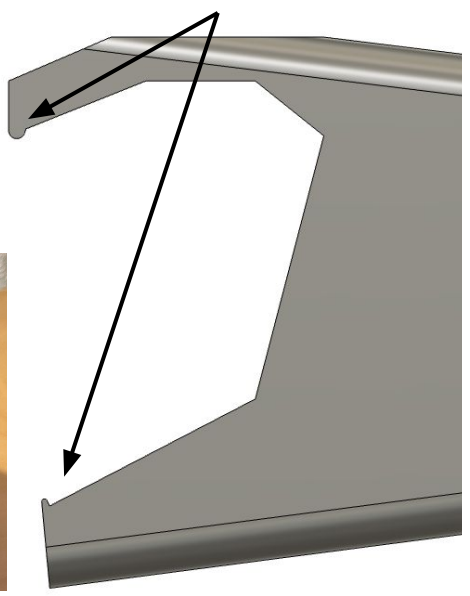
- Stays attached to ipad with low to moderate shaking (not enough adhesion for kids to play with)
- + Won't fall when held sideways



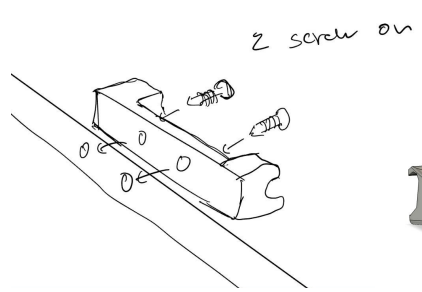
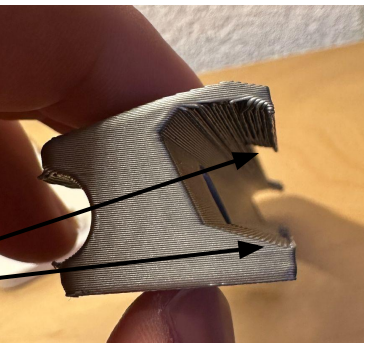
- + Medium strength fit to ipad case
- Separates from 1 meter height drop

2nd iteration "Edge Lips"

Little clips, edge lips for stronger clip on

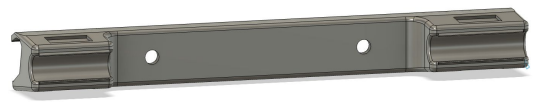


- One large upper lip
- + larger upper lip performs well
- bottom lip provides little benefit
- Two small lips



2 screw on

3rd Idea "Screw on"



Client Feedback

"Easy to clip on but falls off to easy - needs stronger connection"

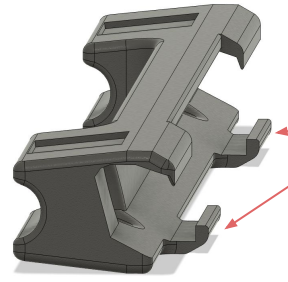
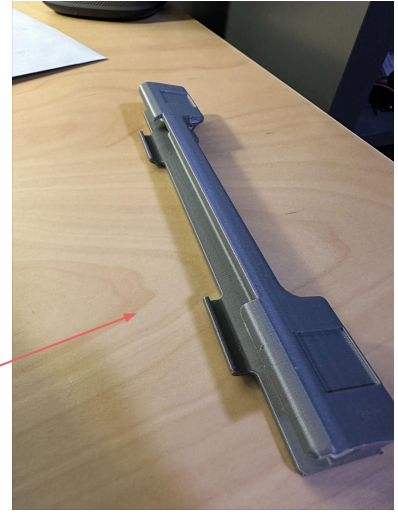
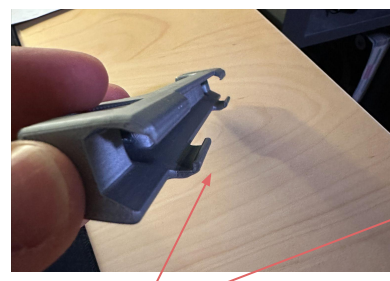
4th iteration "Underside-Hook"



Focused design

Durability and Attachment to Ipad

Backside has indent which the attachment can latch onto



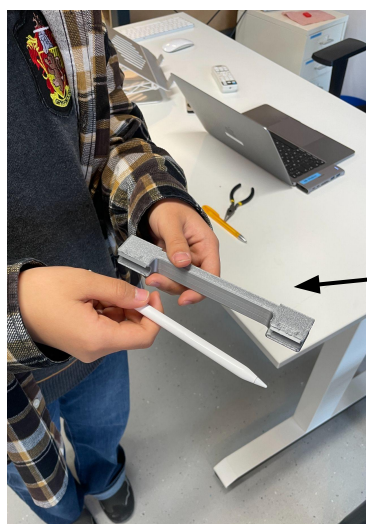
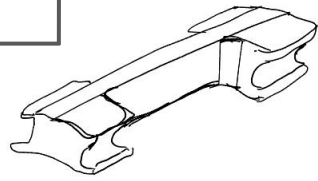
Latches that will hook into backside and clip in

+ Stays attached very well but also clips on and off very easily

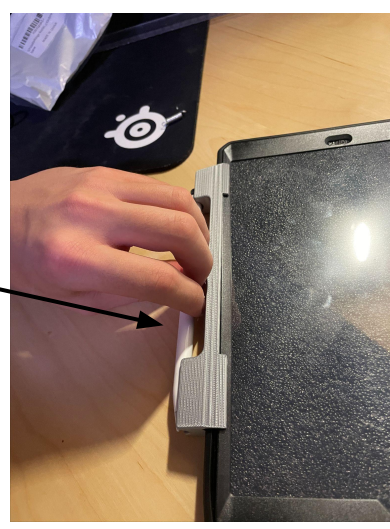
single flat middle grab slot

Ergonomics

1st version "Flat Middle Slot"



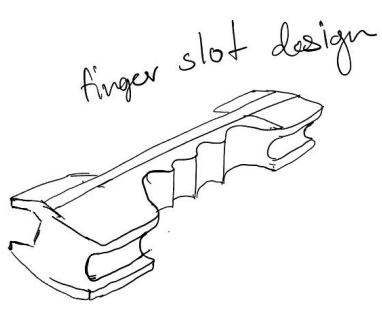
+ finger slot good width for target market



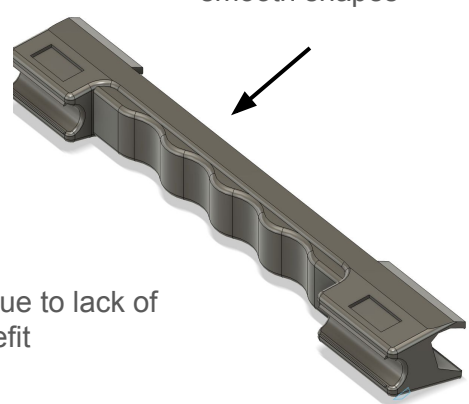
+ easy to reattach to magnets



2nd version "Individual Finger Slots"



Could be appealing to younger children due to friendly design and smooth shapes



*Not developed further due to lack of functional benefit

Client Feedback (Childcare Providers)

"Good ergonomics for pulling off, easy to grab"

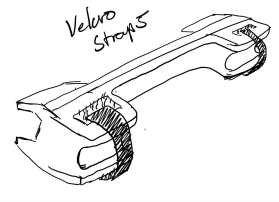
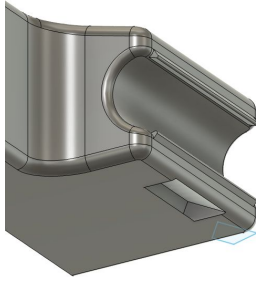
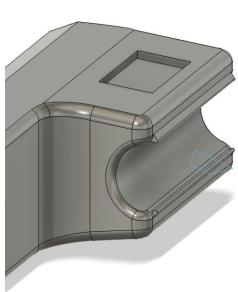
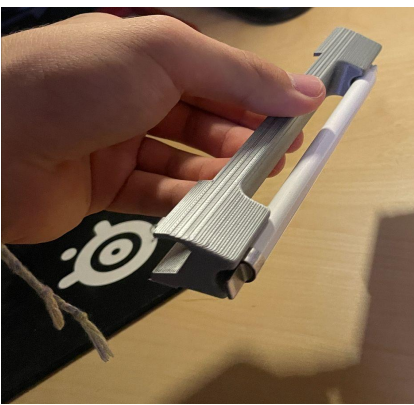
"If they grab it with a fist it will be hard for them to attach, maybe increase the gap"

Focused design

Pen attachment security

3rd version

Velcro straps for more secure protection



1st version

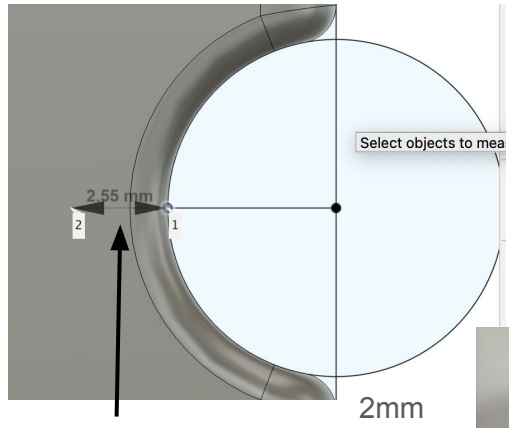
"2 magnets with min Gap 2.45mm"

Moderately strong magnetic connection



2nd version

Reduced distance between magnet and pen for higher strength



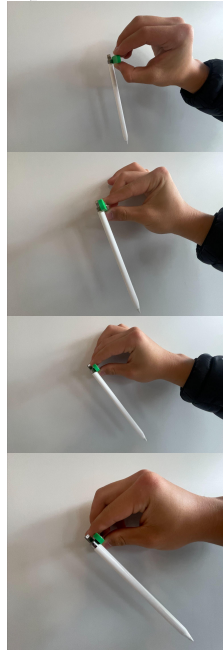
2.45mm PLA between magnets and pen

2mm

1.5mm

1mm

0.5mm

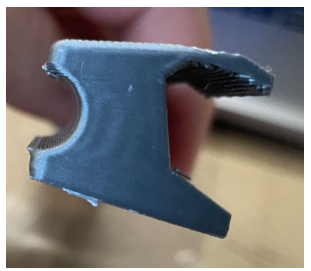
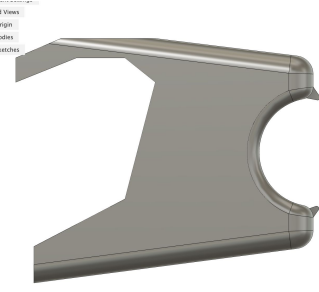
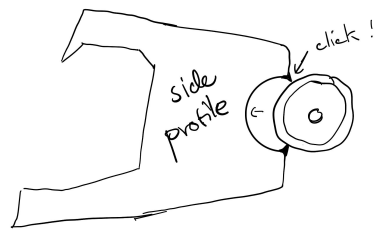


Self made PLA thickness tester 0.5, 1, 1.5, 2mm



4th version

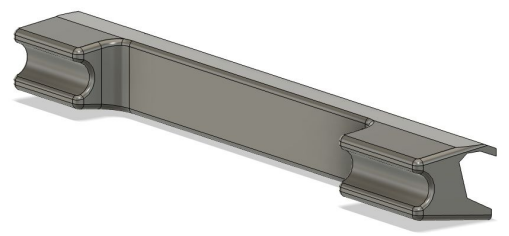
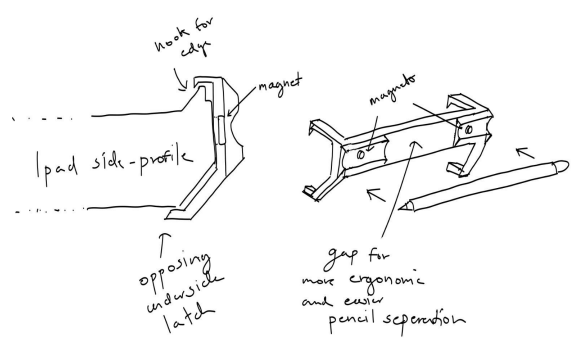
Lipped edges for clip in in addition to magnets



"Too hard to put back on, I feel like I'm gonna break it"

Client Feedback
"Too hard to clip in"

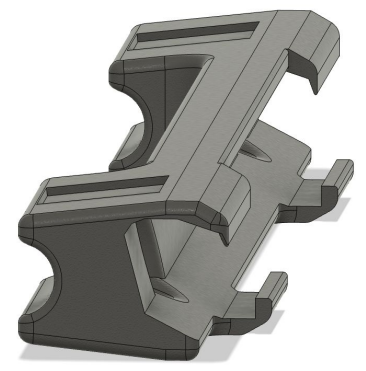
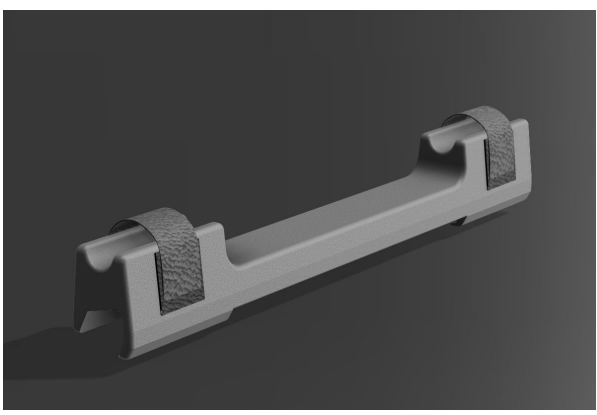
Design 2 Process



6

5

4



Design 2 is the concept that meets the majority of the specification points and has been selected for further development. This design stands out for its safety, simplicity, and ease of use, especially for children. A prototype has been created to evaluate the design's performance and reliability. Through iterative testing and analysis, adjustments were made to ensure greater rigidity and stability. By using CAD models and physical prototypes, the design has been refined to meet ergonomic and functional requirements effectively.

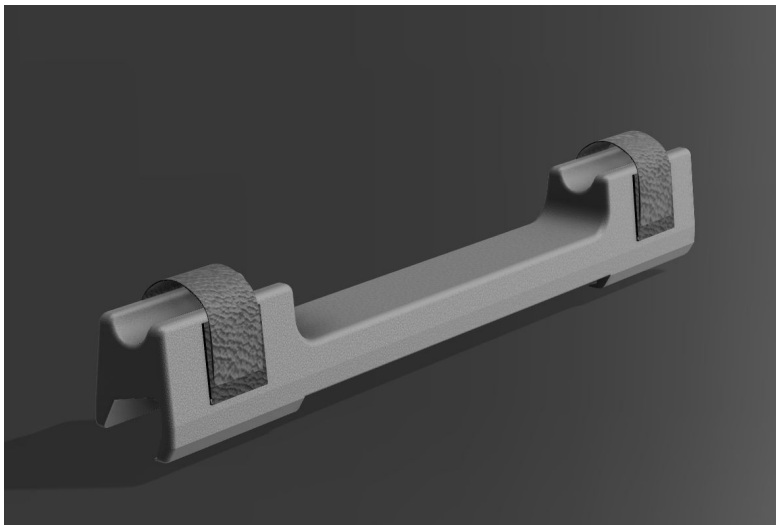
Client feedback was integral to the refinement process, ensuring the design addresses user needs and expectations.

Client Feedback:




"Design 2 is excellent due to its durability and safety features. It feels secure and easy to handle, making it suitable for children. The design also minimizes moving parts, which reduces maintenance and risk of failure. I think it would meet our school's needs well."

Final Design against each Specification Point

Specification	Justification
1.1	Will minimize the chance of electronic waste (loss of apple pens)
1.2	Must stay in tact after 20 drops from 1.5 m height
1.3	Strong attachment to ipad (3N to separate apple pen)
1.4	Safe for young children to use
1.4a	All edges must be rounded
1.4b	Can be no air gaps which can pinch
1.4c	Can't have small parts less than 5x5x5 cm
2.1	Should come in pastel blue or green colors
2.2	Sleek and simplistic design
3.1	Will be used by young children aged 5 - 11.4 who are in school
3.2	Designed for 5th percentile in the age range 5 - 11-4
4.1	Intended for school environment
5.1	Non - toxic materials
5.2	High impact resistance and toughness
6.1	Should be no larger than 260mm (length) x 190mm (width) x 20mm (height)
6.2	Must weigh less than 250 g - Portable and lightweight
7.1	Manufactured with school equipment or from an outsourced workshop (local)
8.1	Will construct a one-off prototype





Appropriate Materials - Frame

Materials	PLA (Polylactic Acid)	ABS (Acrylonitrile Butadiene Styrene)	PETG (Polyethylene Terephthalate Glycol)
			
Properties	Lightweight, biodegradable, easy to print	Durable, impact-resistant, higher melting point	Good balance of flexibility and strength
Availability and Cost	Widely available, affordable (\$20-\$30/kg)	Widely available, affordable (\$20-\$40/kg)	Available, slightly higher cost (\$25-\$35/kg)
Environmental Impact	Biodegradable, eco-friendly	Non-biodegradable, higher environmental impact	Recyclable, lower impact than ABS
Positives	Easy to print, good surface finish	Strong and durable, suitable for functional parts	Strong, durable, minimal warping
Negatives	Limited heat resistance, can be brittle	Emits fumes during printing, requires ventilation	More challenging to print than PLA
Score	4.5/5	3/5	4/5

Conclusion:

Referring to the same criteria for the iPhone attachment, the best and most suitable material for the prototype is PLA. Its lightweight nature and ease of printing make it ideal for creating precise, small-scale components that are comfortable for users to handle. Additionally, PLA's cost-effectiveness and biodegradability align with sustainable practices. Its availability in most school and home 3D printing setups simplifies the manufacturing process. Despite its limited heat resistance, PLA provides sufficient durability for everyday use, ensuring a balance of practicality and environmental consciousness.

Appropriate Materials - Components

Materials	Properties	Availability and Cost	Environmental Impact	Positives	Negatives
Velcro 	Flexible, durable, reusable	Widely available, low cost	Low environmental impact, reusable	Easy to attach/detach, adjustable	Limited strength, may wear out over time
Magnets 	Strong magnetic pull, reusable	Widely available, medium cost	Moderate impact, mining required for materials	Secure attachment, no mechanical wear	Can lose magnetism over time, bulky
Glue	Toughness, Abrasion resistant	- Provided at school	Can be flammable, if improperly disposed it can damage the soil	Strong bond between two surfaces	Low impact resistance

Conclusion:

Using magnets and velcro combined work best to connect the attachment securely to the iPhone. The strong magnetic pull ensures a reliable bond that prevents accidental detachment, enhancing the functionality of the prototype. The availability and reusability of magnets make the manufacturing process efficient and sustainable. Although magnets can lose magnetism over time, their overall durability and convenience outweigh this drawback. Additionally, velcro serves as a useful addition to offer an additional more robust and stable solution for long-term use and safety of attachment.

Manufacturing Techniques

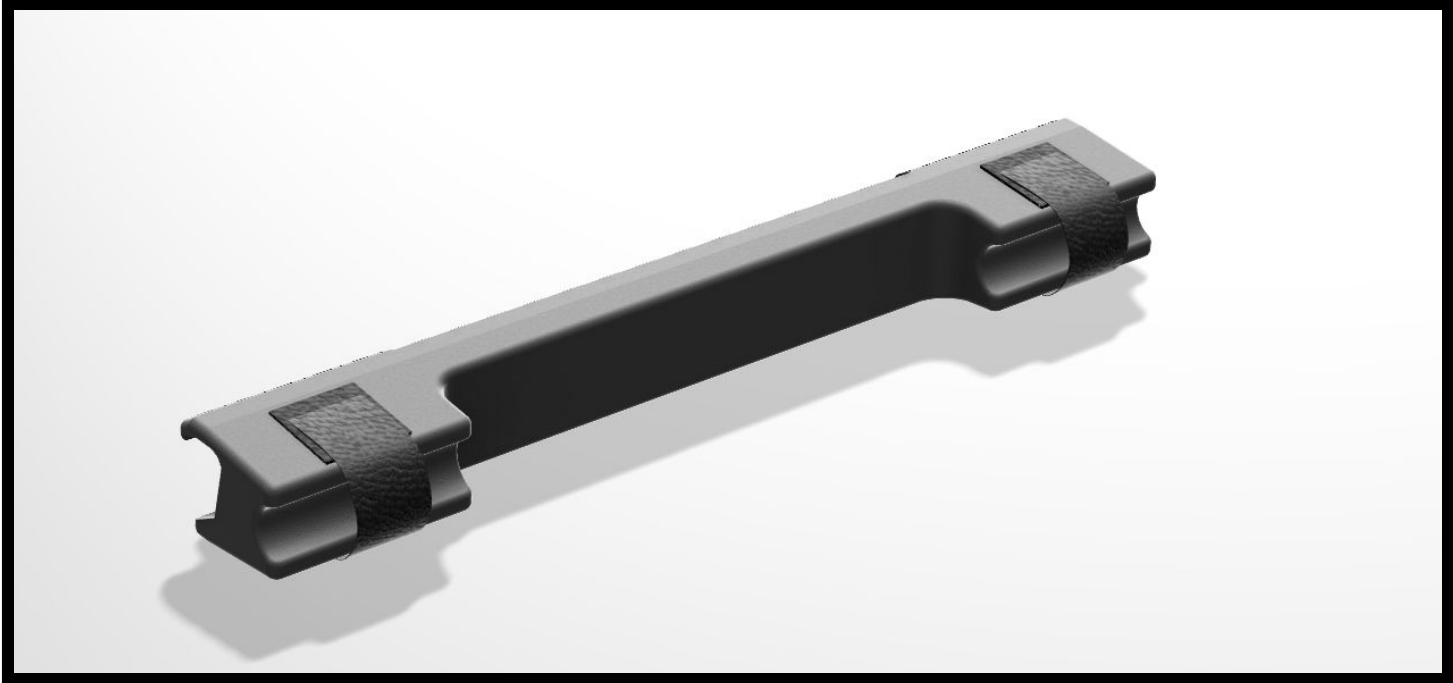
Manufacturing Technique/Process	Advantages chosen for design	Disadvantages chosen for design	Material suitability
Fusion 360	Allows precise digital modeling, customizable designs	Hard to learn and use effectively	Software
3D printing	High accuracy, creates complex shapes easily	Time-consuming, may have size limitations	PLA, PETG, ABS
Sanding	Provides a smooth finish and precise shaping	May not work well for very hard materials	PLA, PETG, ABS
Glue	Creates a strong bond, easy to use, available	Can be weak under high stress or heat	PLA, PETG, ABS

Conclusion:

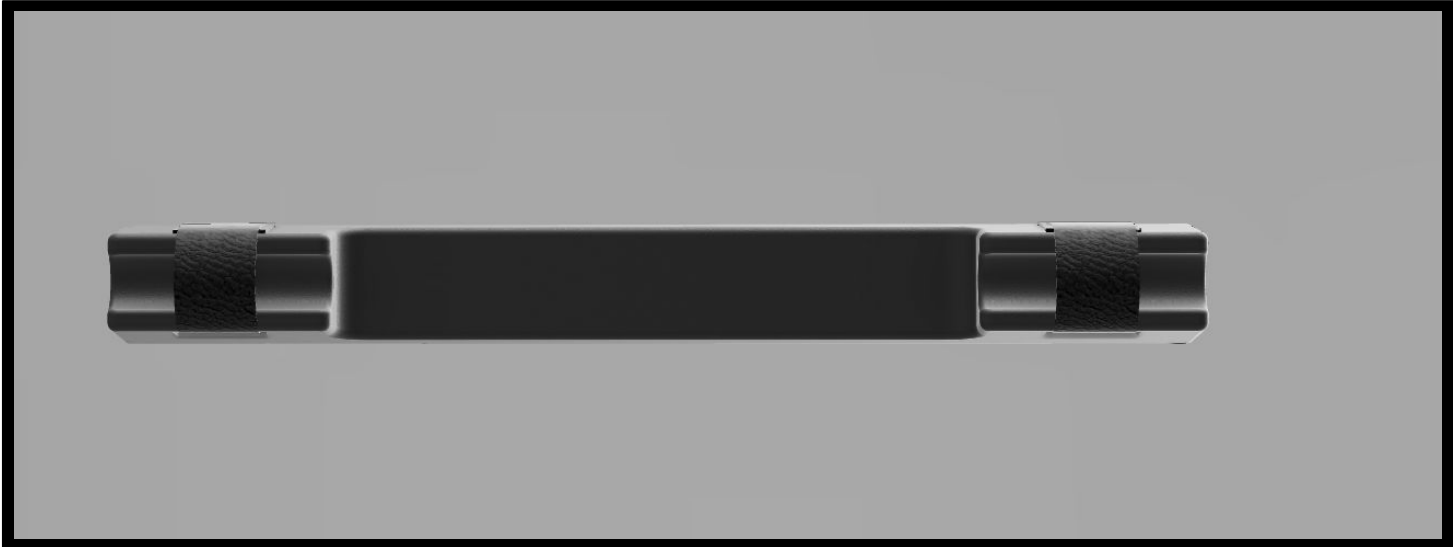
Fusion 360 and 3D printing are optimal for designing and producing the iPhone attachment due to their precision and customization capabilities. Sanding ensures a smooth, polished finish, enhancing usability. Glue provides effective bonding for reliable assembly. Together, these methods create a durable and aesthetically pleasing product.

Final Renders

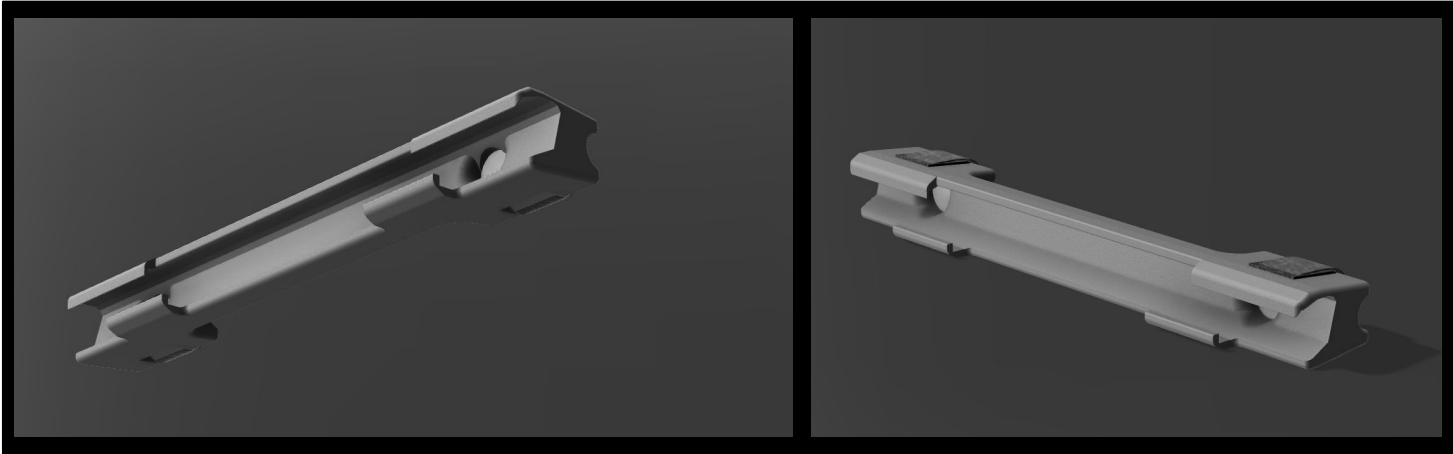
Top Side View



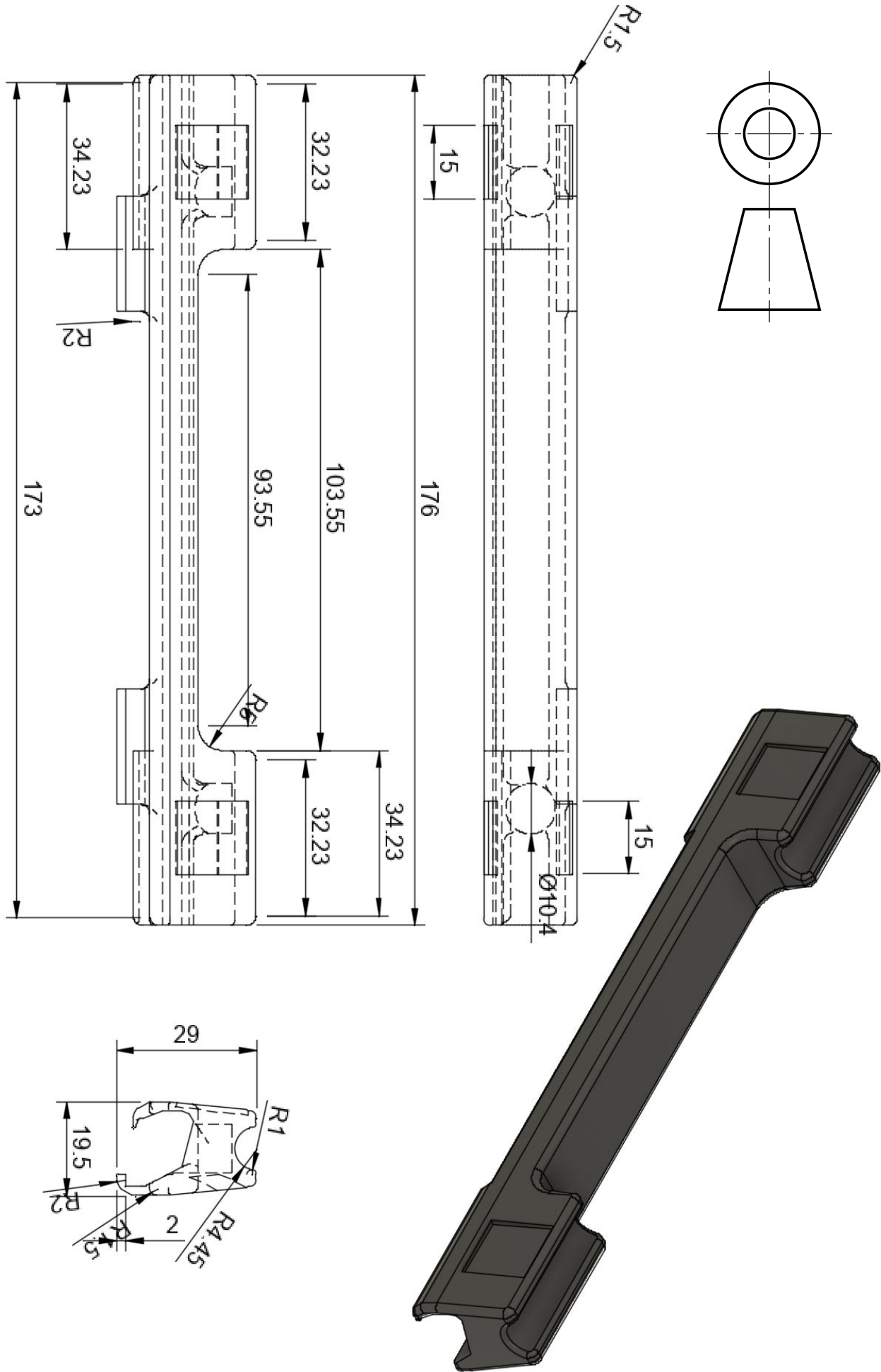
Front Side View



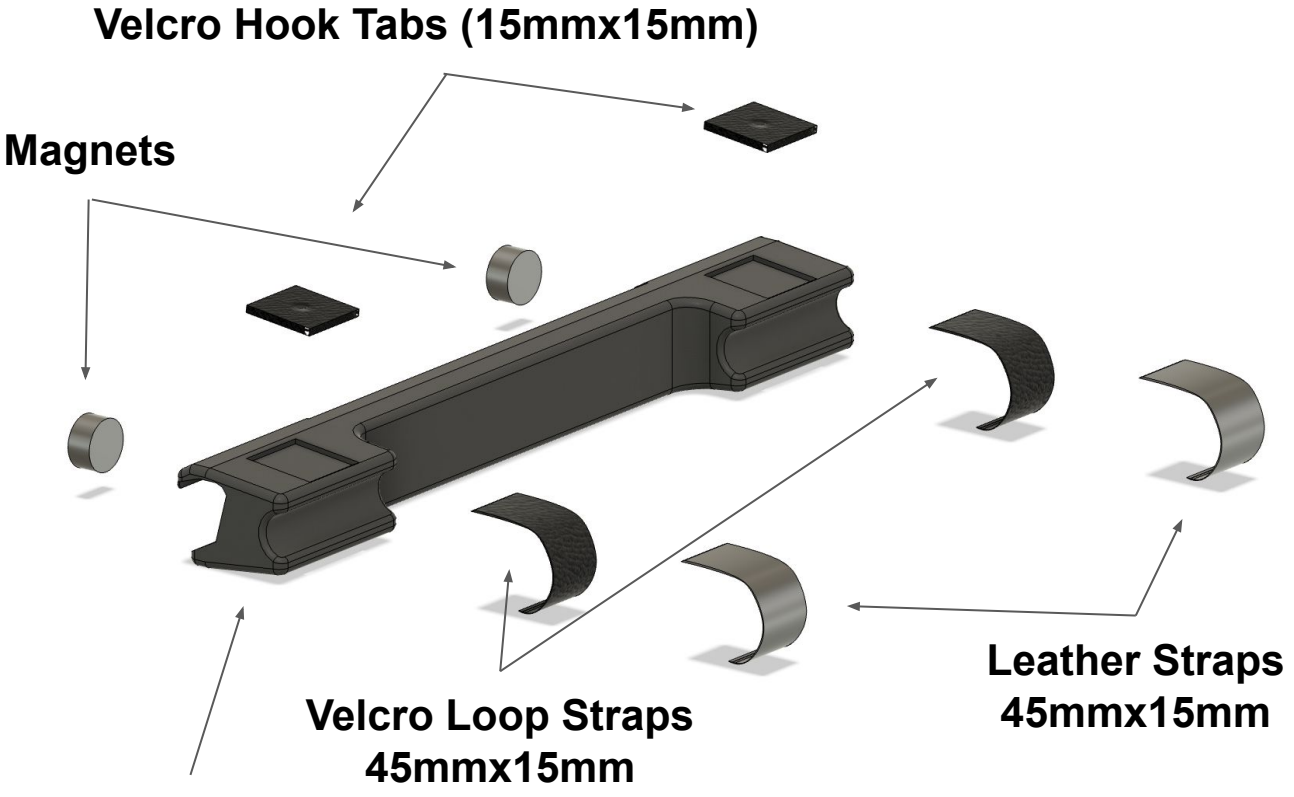
Bottom and Rear Side Views



Orthographic Drawing

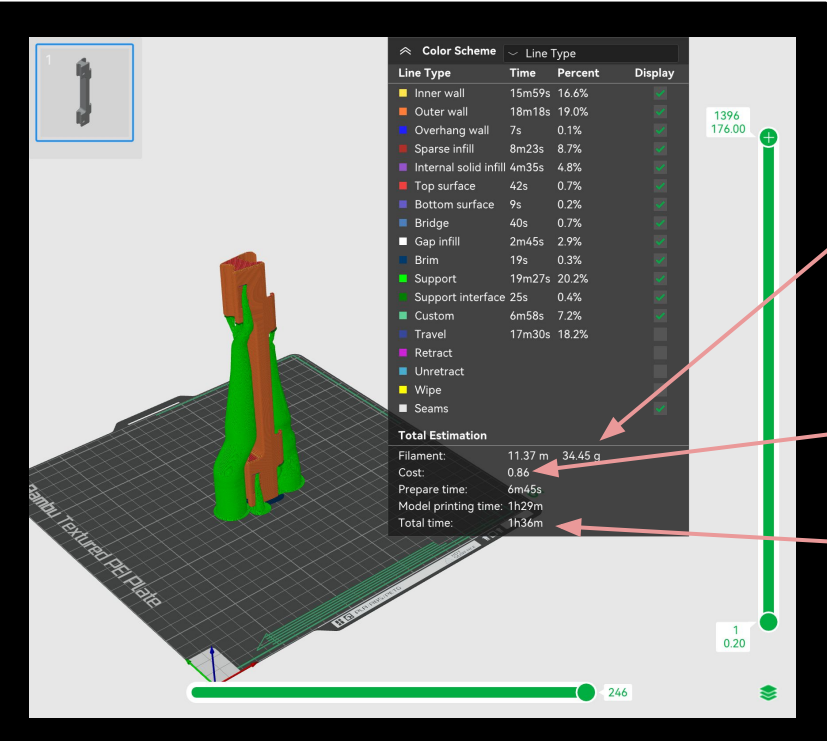


Exploded Drawing of Components



PLA Main Body

Manufacture Time



Filament Mass: 34.45g

Filament Cost: 0.86 Euro

Total Print Time: 1h36m

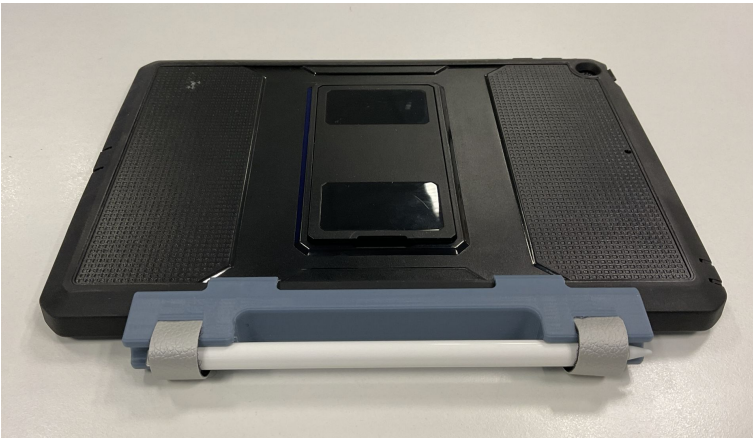
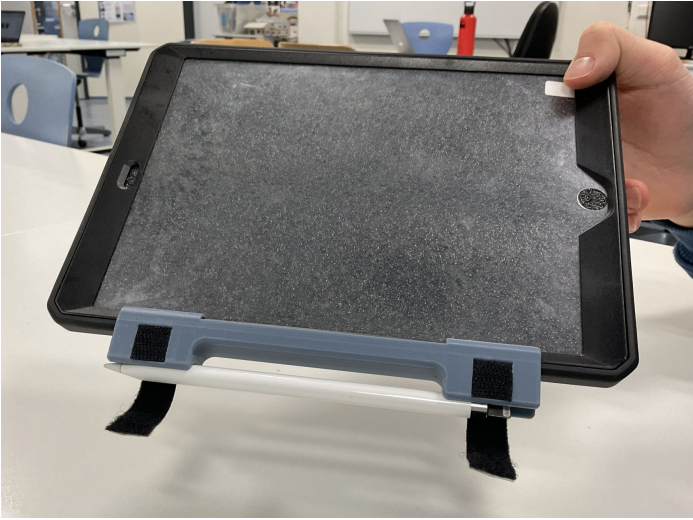
Bill of Materials

Component	Material	Size (mm)	Quantity	Finish	Cost (€)
Frame	Pla		1	Matte	0.86 (Bambulab.com)
Magnets	Magnet	10x5 circle	2	N/A	0.34 (Amazon.com)
Velcro Loop	Velcro (Loops)	10 x 50	2	N/A	0.16 (Amazon.com)
Velcro Hook	Velcro (hooks)	15x15	2	N/A	0.16 (Amazon.com)
Leather Strap	Leather	10 x 50	2	N/A	0.53 (Amazon.com)

Manufacturing Process

Processes	Equipment	Scheduling	Quality Control	Risk Assessment
1. Design the product in Fusion 360	- Fusion 360	30 min	Verify dimensions and tolerances to ensure proper functionality	Screen time and risks of losing file from not saving frequently and check for errors before exporting
2. Export design to STL format and prepare for 3D printing	- Fusion 360 - 3D Printer Software	10 min	Ensure STL file is optimized, support material type is chosen and slice settings are correct	Save design locally and on cloud to avoid data loss
3. Print the product using PLA material	- 3D Printer - PLA filament	1:36 hours	Monitor the print for errors (e.g., stringing, nozzle clogging)	Ensure ventilation is adequate and avoid touching hot components after print
4. Remove excess material and sand the product	- Sandpaper	15 min	Ensure all excess supports or brims are removed cleanly	Wear gloves and goggles to avoid injury from sharp or abrasive edges
5. Sand or Polish if print quality is poor	- Sand paper	20 min	Inspect the surface for smoothness and proper coverage	Work in a ventilated area and use eyewear
6. Attach Velcro and magnets	- Velcro, magnets and adhesive	30 min	Test attachment to ensure secure fitting and proper alignment	Avoid using excessive adhesive, and ensure proper drying time

Final Product



Design Specification Evaluation

Specification	Testing Strategy	Justification	Data Generated
FUNCTION	User Trial and Quality Assurance (QA): Tested against each specification visually and by users from the target audience. Also includes quantitative testing with measurement tools (e.g., load tests, stability assessments).	Allows for observation of how the user interacts with the product, ensuring it meets portability, stability, comfort, and intended functionality. Identifies areas for improvement.	Qualitative and Quantitative (e.g., user feedback, stability metrics)
AESTHETICS	User Research: Expert in design consulted about aesthetics. Visual Comparison: Color schemes and finish compared to original specification or design intent.	Expert insights can lead to improvements in visual appeal, branding consistency, and user satisfaction. Enhances overall marketability.	Qualitative (e.g., expert opinion, user aesthetic preferences)
TARGET MARKET	Field Test: Prototype given to a small group (e.g., 3 users) within the intended market segment, then rated on suitability and appeal.	Confirms whether the product addresses the needs and preferences of the intended market, ensuring better commercial viability.	Qualitative and Quantitative (user rankings, satisfaction scores)
TARGET AUDIENCE	Literature Search & Survey: Dimensions and features assessed against anthropometric data and user surveys for the intended age range or demographic.	Validates that the product's size, form, and features align with the physiological and cognitive abilities of the target audience, improving user-friendliness and safety.	Qualitative and Quantitative (survey feedback, dimension checks)
MATERIAL SELECTION	Literature & Standards Review: Verify material qualities, compliance with safety regulations. Mechanical Testing: Drop tests, strength assessments to confirm durability.	Ensures materials meet safety standards (especially for children), durability, and regulatory compliance. Enhances product lifespan and reduces liability.	Quantitative (strength test data, compliance ratings)
SIZE	Mathematical Calculations & Measurements: Compare final product dimensions and weight to specifications using orthographic drawings.	Precise measurement ensures the product meets dimensional specifications, supporting consistency, manufacturing accuracy, and proper fit for users.	Quantitative (dimension and weight data)
QUANTITY	Prototype Production: Manufacture a single prototype for initial assessment.	Building one prototype helps identify manufacturing challenges, validate feasibility, and gather initial data on costs and time before scaling up.	Quantitative (unit cost estimates, time-to-produce metrics)
PRODUCTION CONSTRAINTS	Expert Appraisal: Consult with a manufacturing expert to assess feasibility, tooling requirements, and potential supply chain issues.	Expert input helps optimize design for production, reduce costs, and streamline the manufacturing process. Ensures smoother scaling to mass production.	Qualitative (expert recommendations, identified production bottlenecks)

Design Specification Evaluation

Specification		Results	Success
1. Function	1.1 Will minimize the chance of electronic waste	Figures 1-3 show how product is securely attached to pen	√
	1.2 Must stay in tact after 20 drops from 1.5 m height	Figures 5 and 6 show before and after 20 drops	√
	1.3 Strong attachment to ipad (3N to separate pen)	Figure 4 shows pen stays on lpad up to 10 Newtons of Force	√
	1.4 Safe for young children to use 1.4a All edges must be rounded 1.4b Can be no air gaps which can pinch 1.4c Can't have small parts less than x,y,z size	Figures 1-3 show how filleted edges are smooth, with no air gaps for pinching. No small pieces that could be detached to choke on. Materials are safe for children.	√

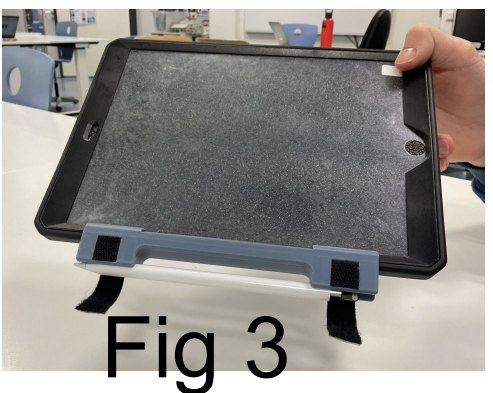
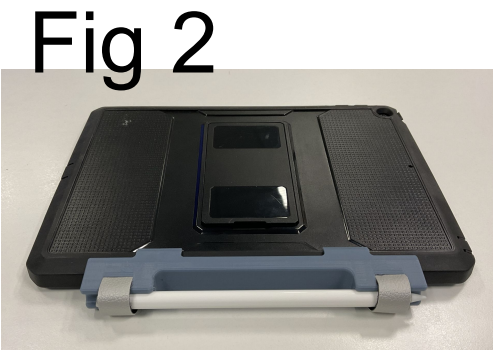
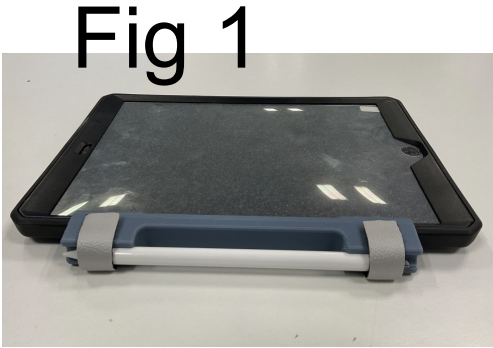


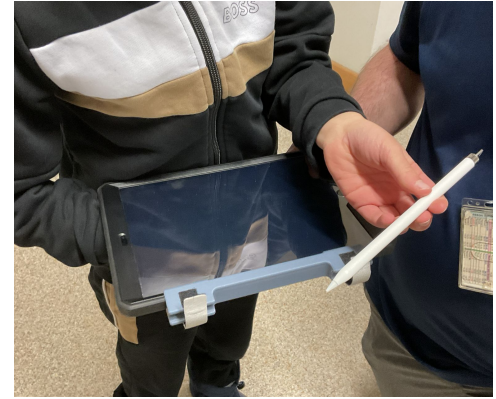
Fig 5

Fig 6

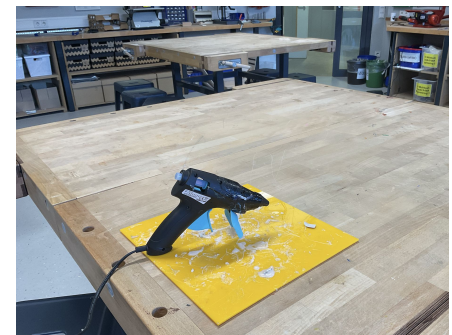


Design Specification Evaluation

Specification		Results	Success
3. Target Audience	3.1 Will be used by young children aged 5 - 11.4 who are in primary/elementary school	Young child testing the final product	√
	3.2 Designed for 5th percentile in the age range 5 - 11-4	Takes much less than 5.4 lbs grip strength of 5 year old to separate pen	√



Specification		Results	Success
4. Target Market	4.1 Intended for school environment	<p>Survey results:</p> <p>Elementary Student: "It would be cool to have that because the pens don't attach and it's a bit easy to lose them."</p> <p>Teacher: "Easy to use and lightweight. Possible improvement, it's difficult to separate, although we only change ipads every 2-3 years. Kids think it looks fun and kids enjoy it."</p>	√



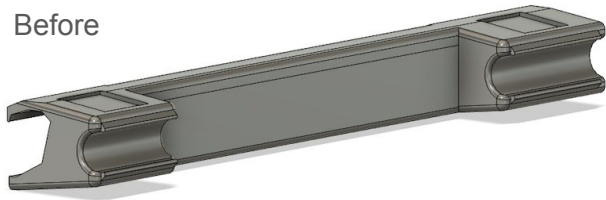
Specification		Results	Success
7. Production Constraints	7.1 Manufactured with school equipment or from an outsourced workshop (local)	Made using in school printer and hot glue	√

Specification		Results	Success
8. Quantity	8.1 Will construct a one-off prototype	Made one-off prototype	√

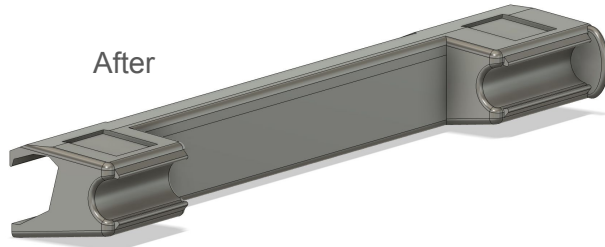


Improvement 1

Before



After

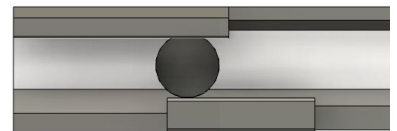


Feedback	Modification	Justification
<p>Slips out sometimes, especially if dropped the wrong way.</p> <p>Childcare providers: “Add a stopper at one or both ends so they can only pull it out one way or so its more obvious how to attach the pen”</p>	<p>Added an elliptical edge piece on one side so the pen can still be removed with Velcro straps on.</p>	<p>The elliptical edge reduces the likelihood of the pen slipping out, improving security while maintaining usability.</p>

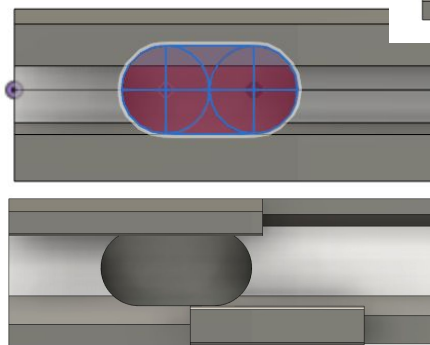
Feedback	Point of highest magnetic effect is too small.
Modification	Added additional circle radius 10.4, increasing the magnet opening area by more than twice.
Justification	Enlarging the magnet opening improves the magnetic grip, ensuring a stronger hold and better overall functionality.

Improvement 2

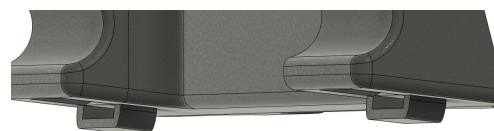
Before



After



Improvement 3



Feedback	Modification	Justification
<p>What if I don't want to use the velcro straps?</p>	<p>Added on a latch at the bottom for velcro to be fixed away from pen storage area.</p>	<p>Prevents the velcro from getting in the way of the magnets when not in use.</p>