The importance of prototyping during product development

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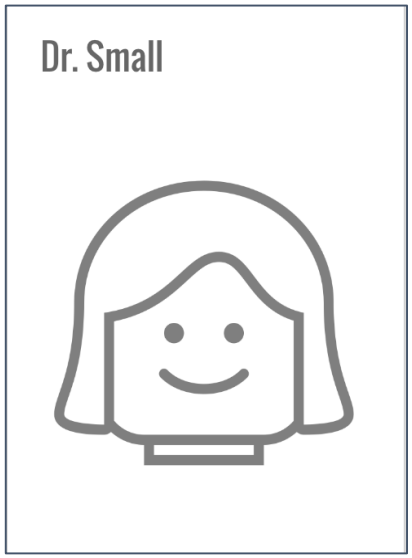
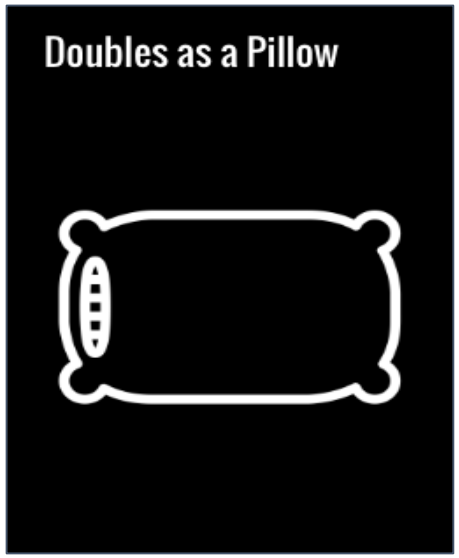
Warm-up prototyping activity: Mockups – *a fast paced game for people who build to think!*

Created by the Delta Lab
Northwestern University

1. **Pick three cards: one of each color**





2. Read and solve the "need". For example, the selection above would be:

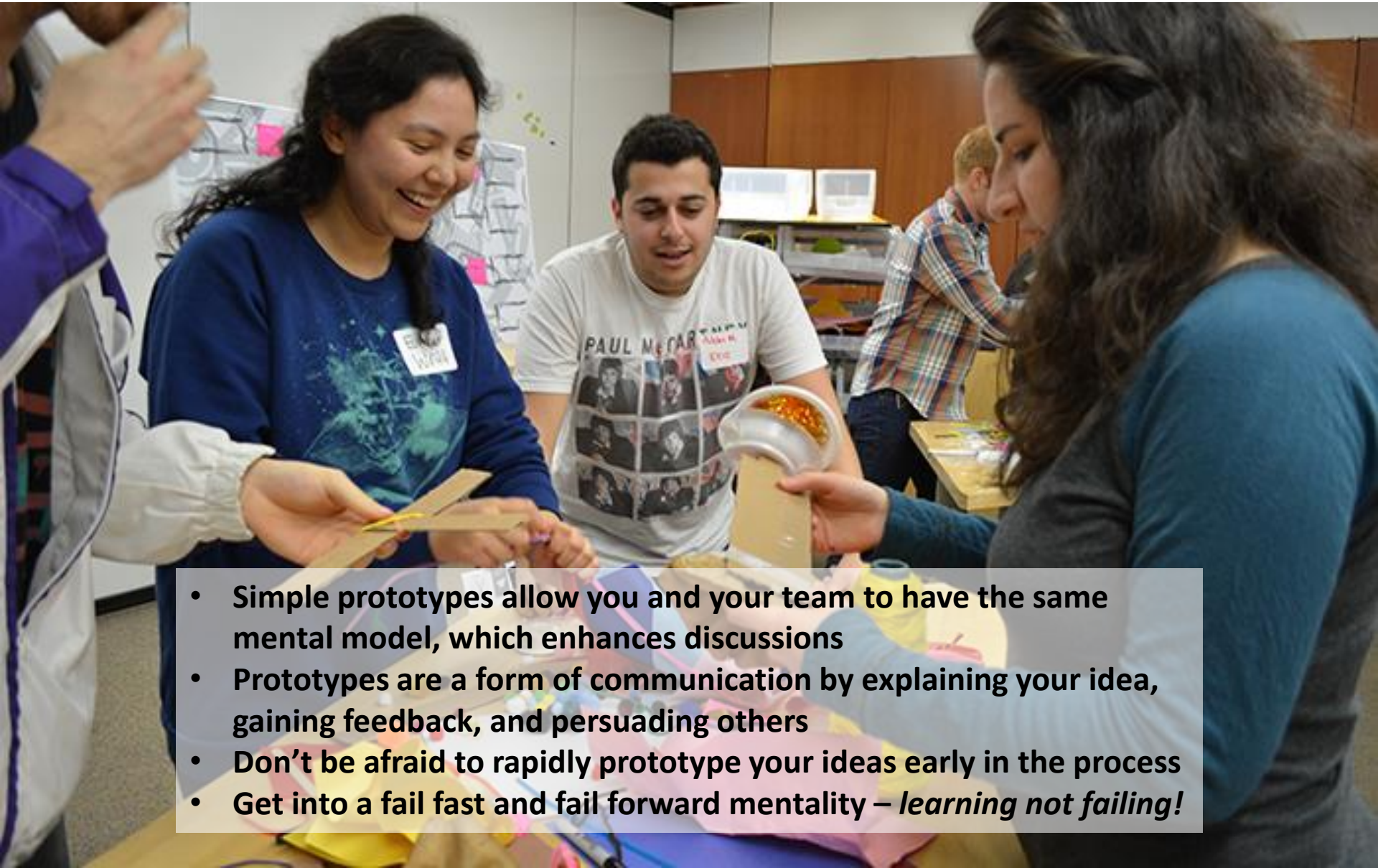
Dr. Small needs a way to travel back in time that also doubles as a pillow.

3. Three teams compete at a time. Each team builds a prototype of your proposed solution to the statement out of any materials provided. You only have 1 minute!

4. Present your prototyped solution to the group in 15 seconds.

5. The audience cheers for their favorite solutions. The loudest cheering wins! ☺

Mockups relate to several of the prototyping principles that I will share today:

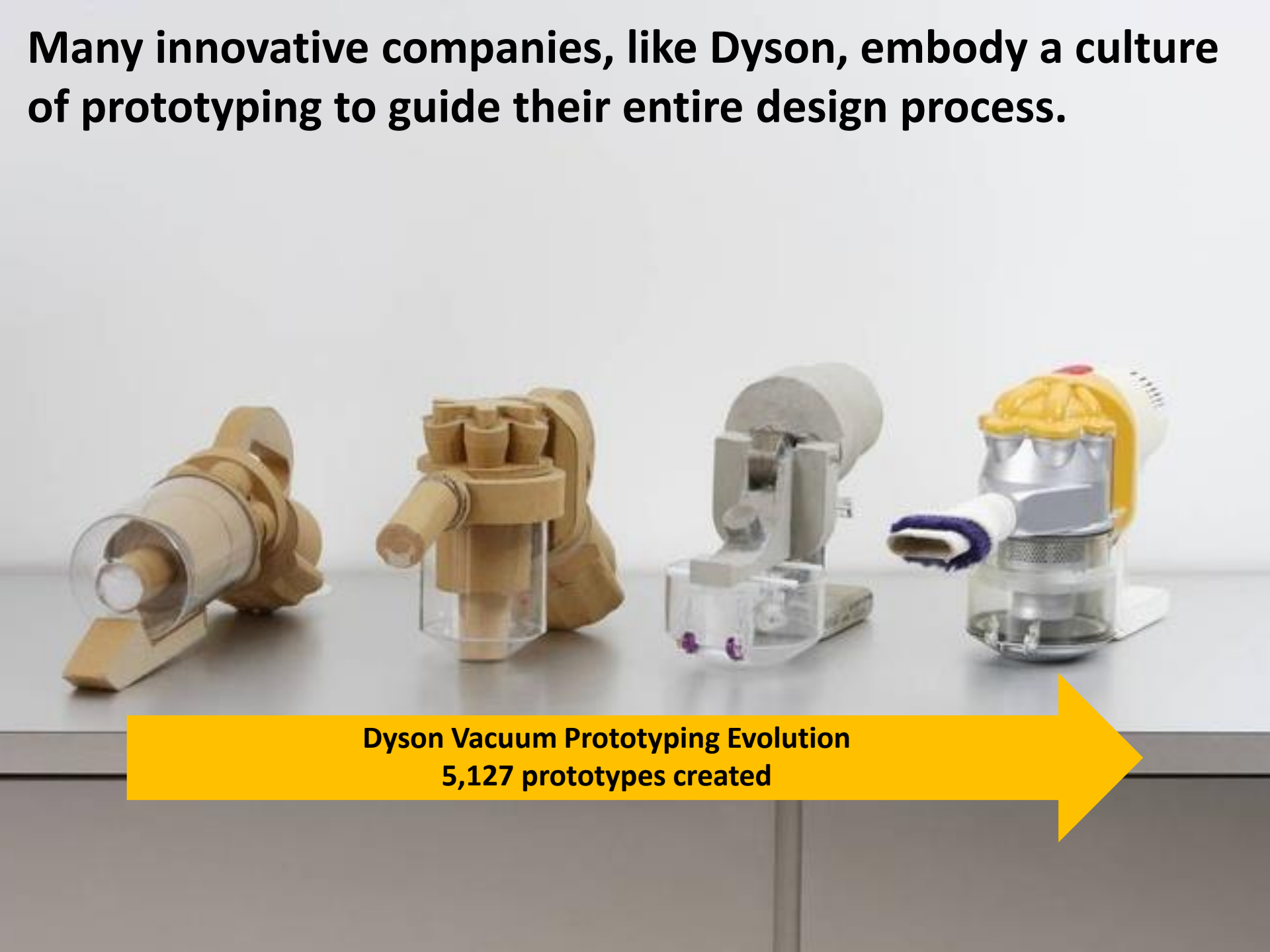


- Simple prototypes allow you and your team to have the same mental model, which enhances discussions
- Prototypes are a form of communication by explaining your idea, gaining feedback, and persuading others
- Don’t be afraid to rapidly prototype your ideas early in the process
- Get into a fail fast and fail forward mentality – *learning not failing!*

The goal of today is to teach a new prototyping mindset and then have you apply it to your specific design projects.

Prototyping is one of the most critical activities in new product development.

Many innovative companies, like Dyson, embody a culture of prototyping to guide their entire design process.



So, what is a *prototype*?

The term *prototype* is confusing, as different fields refer to different mediums and levels of fidelity with the term.

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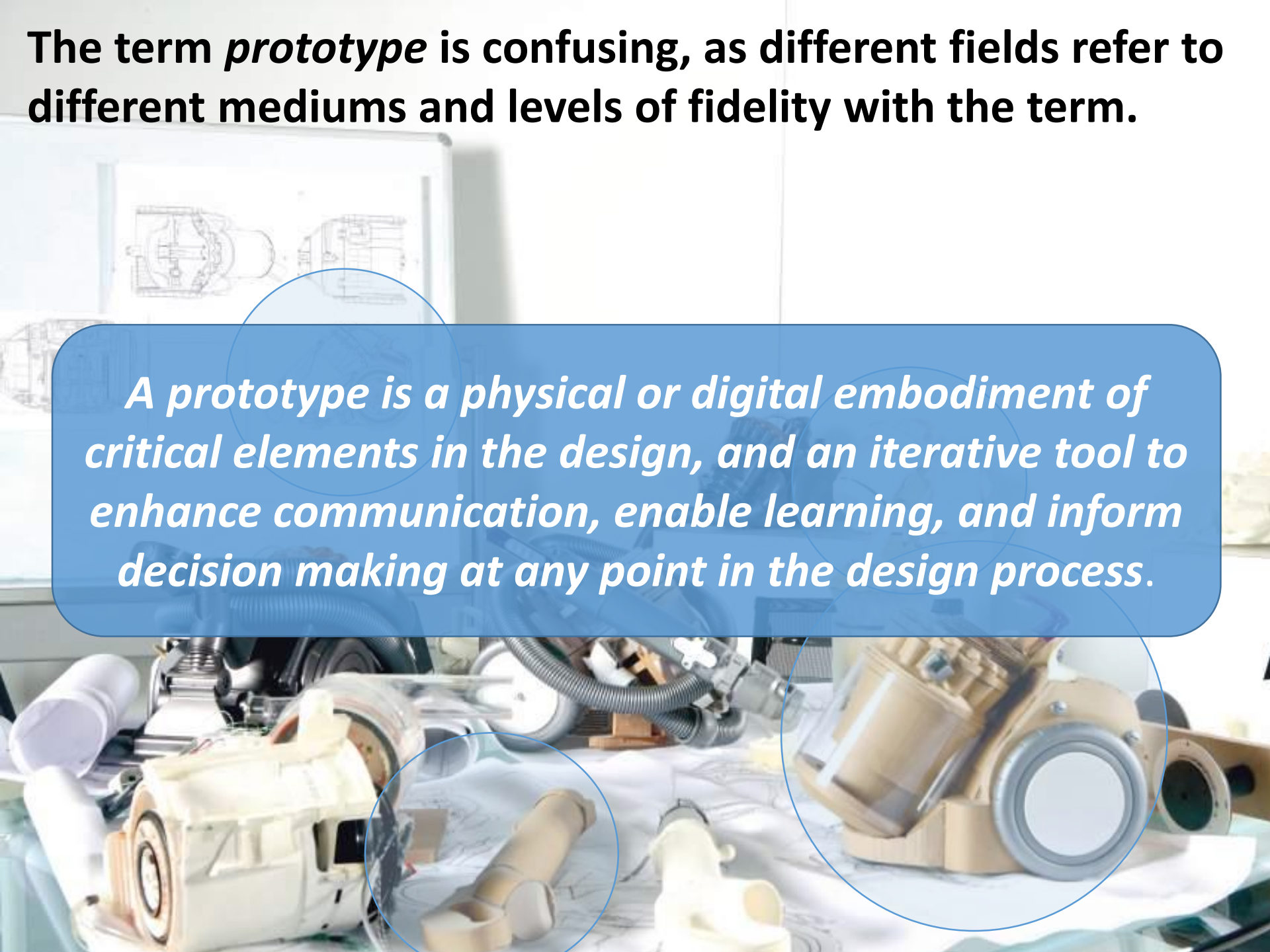
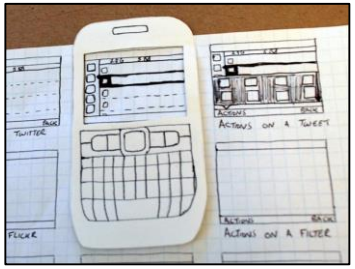
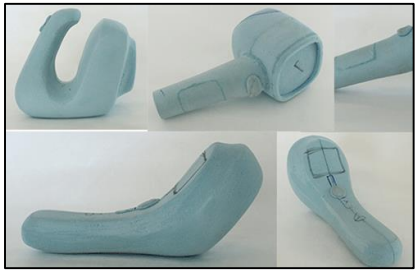


A prototype is a physical or digital embodiment of critical elements in the design, and an iterative tool to enhance communication, enable learning, and inform decision making at any point in the design process.

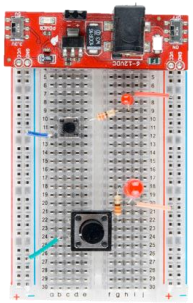
Prototypes are designed to answer questions, and different questions requires different mediums.



Interaction Design –
Simulation of Process



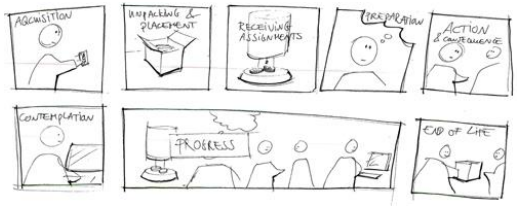
Industrial Design –
Form Models



Electrical Engineering –
Breadboard, Schematic

Product Design –
Simple Concept

Architect –
Model & Rendering

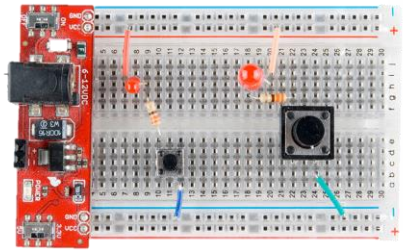


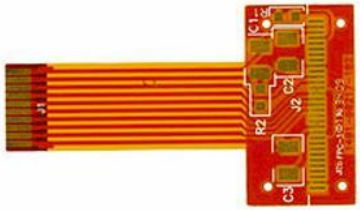
Creative Writing –
Storyboard Process

CompSci –
Test Code/Program

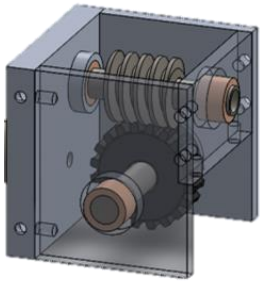
Mechanical Engineering –
Full product design

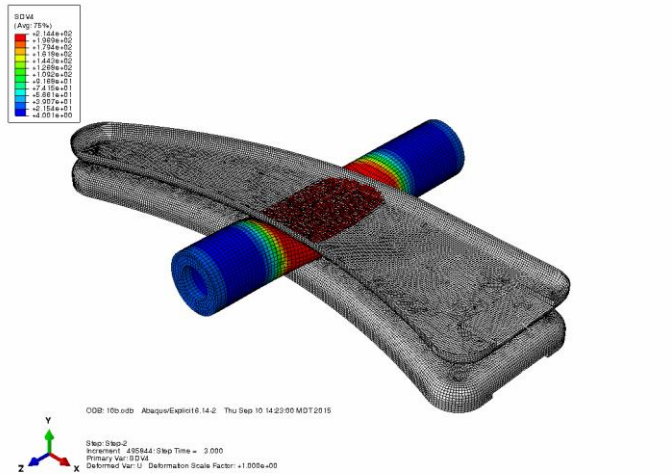
For example, these are all prototypes used in the creation of a thermal tissue fusion medical device.





$$\rho c_p \left(u\frac{\partial T}{\partial r} + w\frac{\partial T}{\partial z} \right) = \kappa \left\{ \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r} \right) + \frac{\partial^2 T}{\partial z^2} \right\}$$
$$+ \mu \left\{ \left(\frac{\partial u}{\partial z} \right)^2 + \left(\frac{\partial v}{\partial z} \right)^2 \right\} + \sigma B_0^2 (u^2 + v^2),$$





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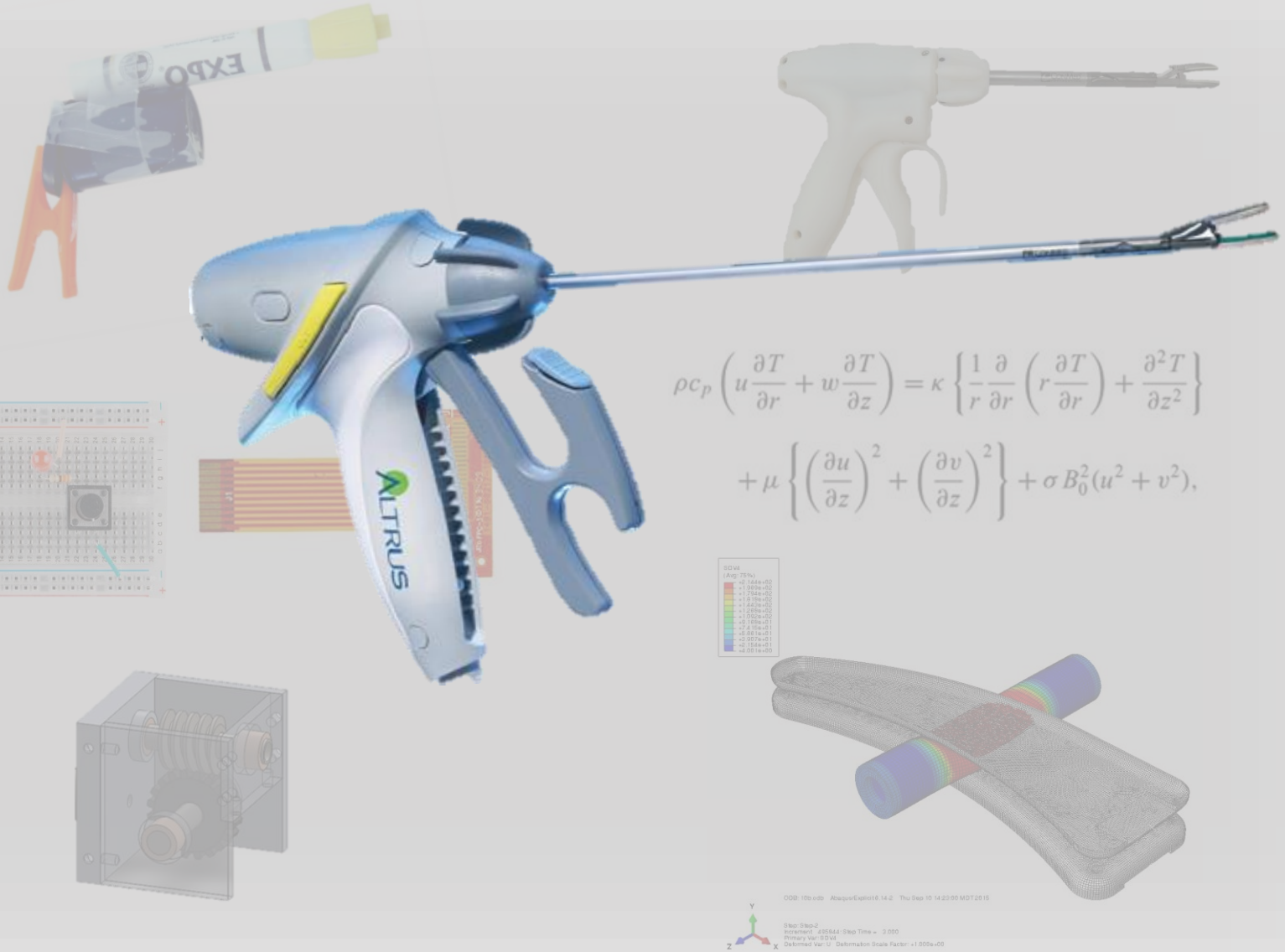

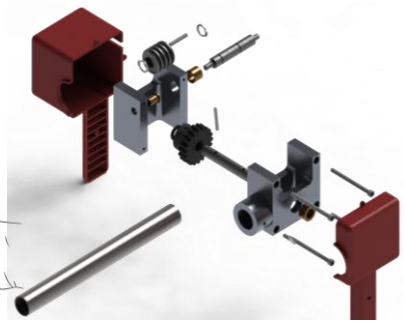

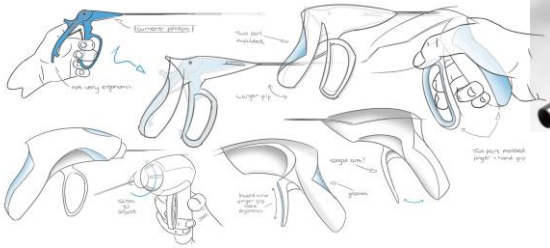

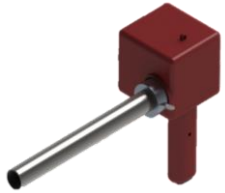

Digital / 2D

Full system / Product

Physical / 3D

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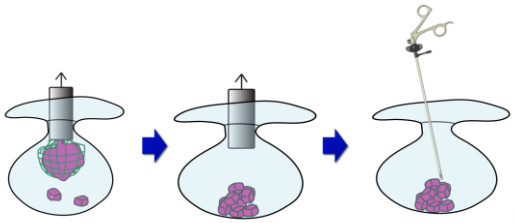
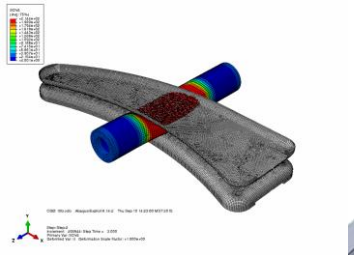
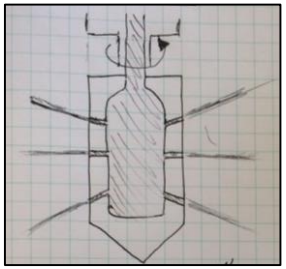
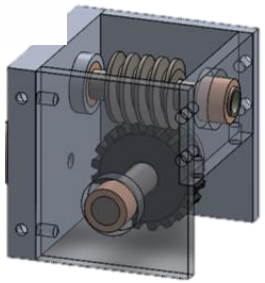
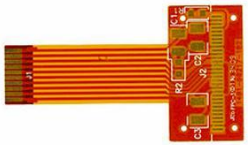
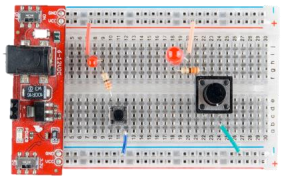


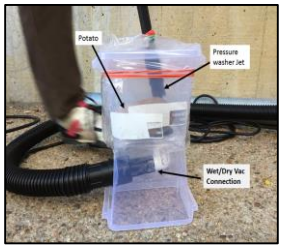












Components / Sub-systems

Questions
(drive the medium)

Lessons Learned
(from proper testing)

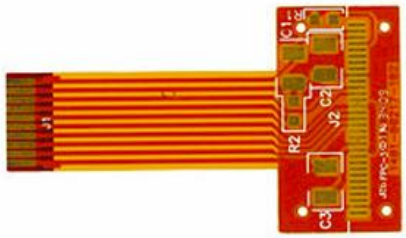
What is the general size of the device? What are some critical aspects to consider?

Client comments on the length of the probe and the angle of the handle.

Can we fit all the components within the housing? Is the force of the grip appropriate?

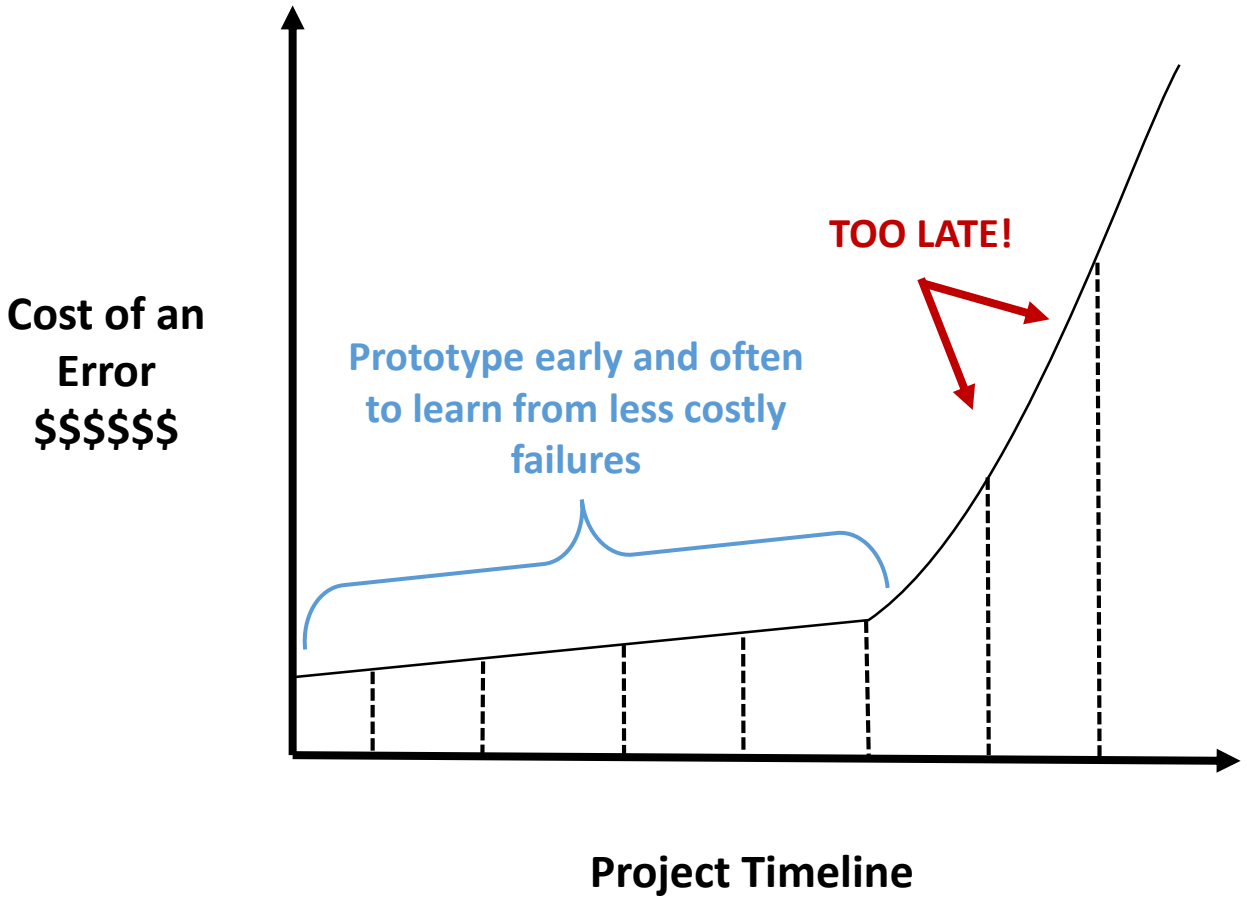
Team learns about handle force and angle, which then alter the next iteration.

Does this flexible PCB integrate into the device? Is the electrical-mechanical communication working?

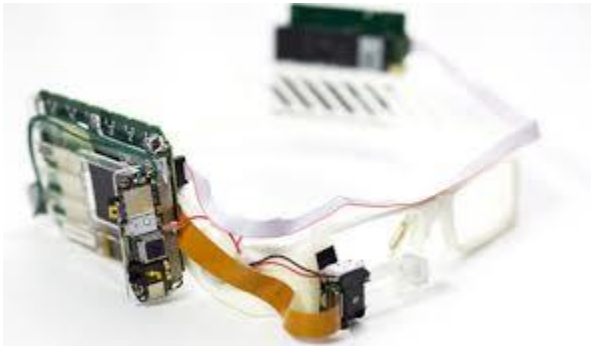


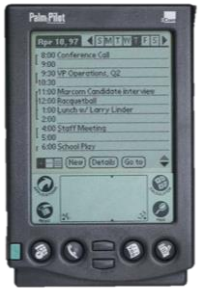
Team finds out that there is not enough space for components, and that it is communicating.

Prototyping should be done early and often to avoid critical failures near the end of a project.



Early prototypes can be called pretotypes: *make sure you are building the right "it" before you build "it" right!*





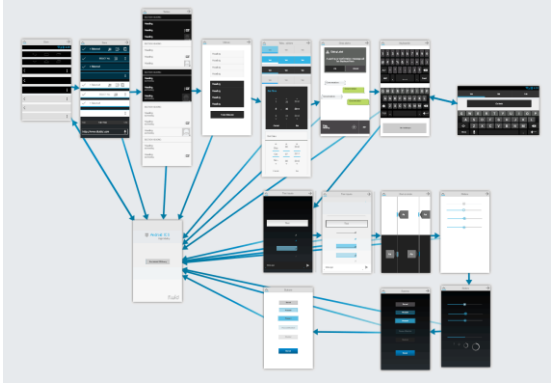
PRETOTYPING (verb): Validating the market appeal and actual usage of a potential new product objectively and with the smallest possible investment of time and money.

We have summarized 10 prototyping principles:

1. You can prototype **anything**.

You can prototype anything from products, processes, and services.

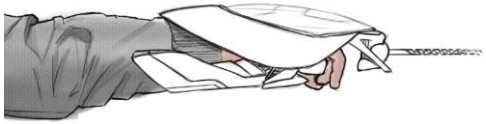
Product



Process

Service/Experience

Likewise, you can prototype new, improved, or platformed designs.



New

Improved

Platformed

We have summarized 10 prototyping principles:

1. You can prototype **anything**.
2. Prototypes can be **various levels of fidelity**.
3. Prototypes can be represented in **many mediums**.
4. Prototypes need an **underlying purpose**.
5. Prototypes **answer questions** related to desirability, viability, and feasibility.
6. Prototypes need **feedback** through specific use case exploration.
7. Prototypes are **iterative** through rounds of testing and feedback.
8. Prototype **failure** can always be reframed as a learning opportunity.
9. Prototypes are a **tool**, not just merely a stage in the design process.
10. Prototypes enable **communication**, inform **decision making**, and aid in **learning**.

There are three overarching roles of a prototype: enable communication, aid in learning, inform decision making.

Prototype Roles

Enables Communication

- Explain
- Feedback
- Negotiate
- Persuade

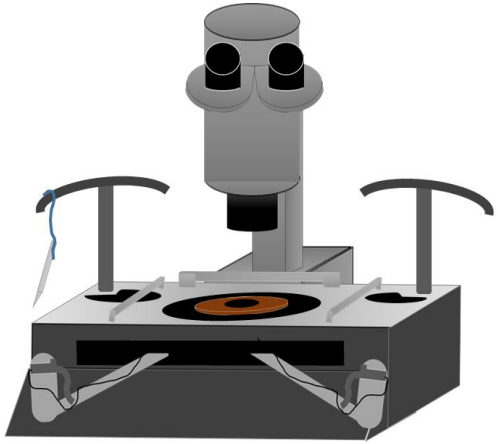
Aids in Learning

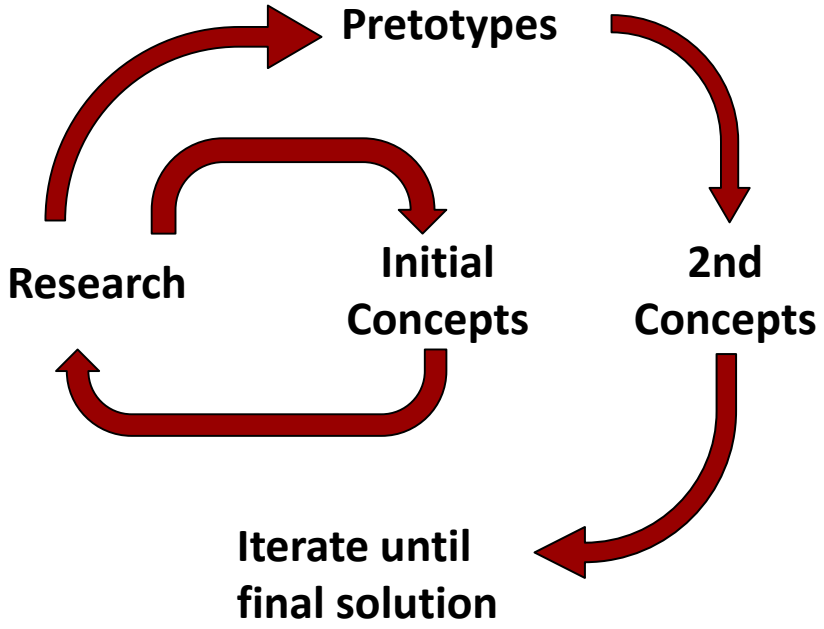
- Product space
- Technical elements
- User interests
- Business aspects

Informs Decision Making

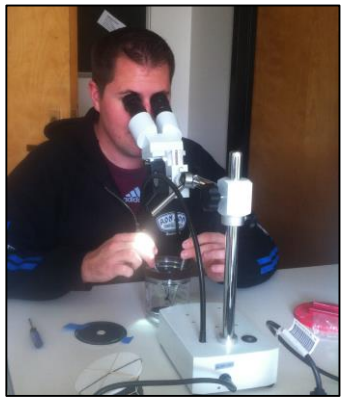
- Feasibility
- Desirability
- Viability

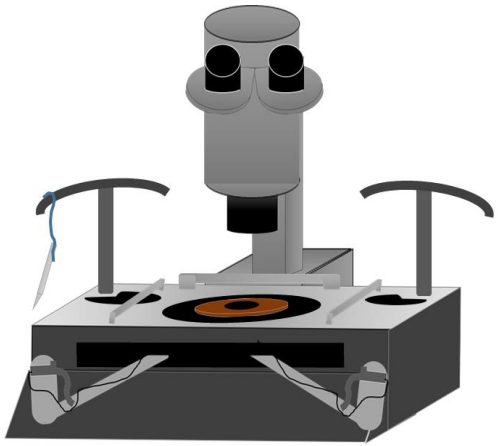
Now, let's walk through a design project to see how this team used prototypes throughout the process.

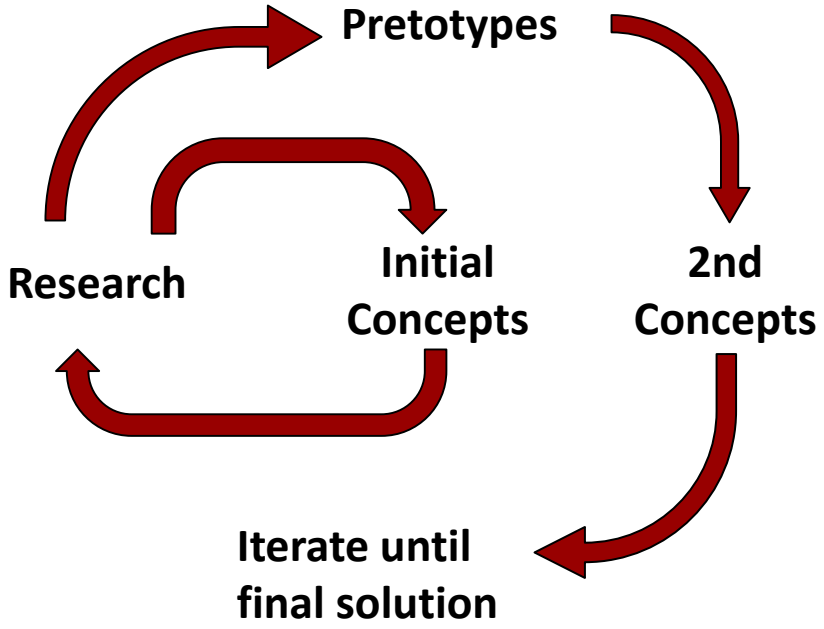




This graduate design team was tasked with developing a training device for neurosurgeons.







Pretotypes were created early to better *understand the requirements* of the project.

Microscope + ruler
to determine eye piece comfort height

Module + protractor
to determine module angle range

Microscope + tools
to determine best way to hold tools

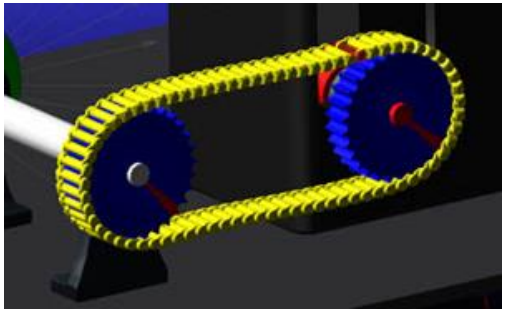
Pretotypes answered simple, yet important questions that impacted decisions moving forward.

Movement/Height
to determine comfortable operating hand height

Tool Interference
to determine minimum microscope range

Tool Apertures
to determine best range for tool aperture

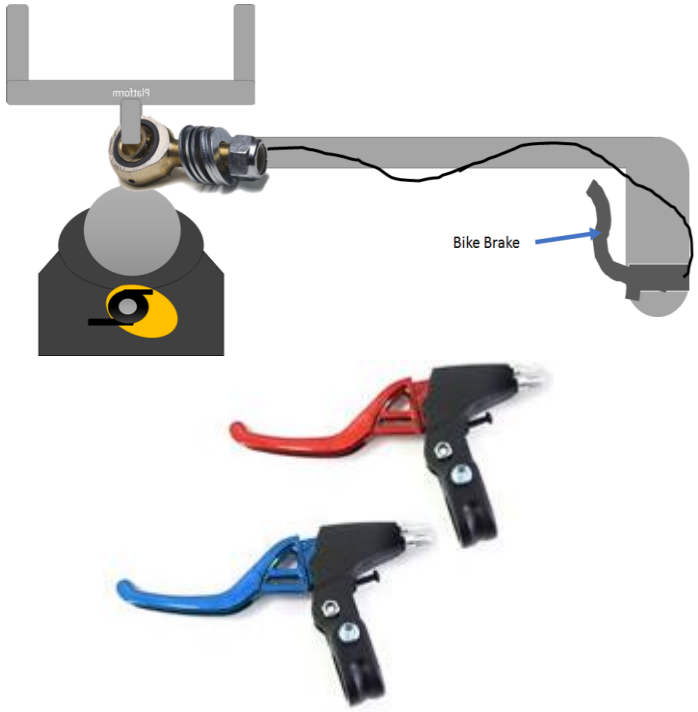
After answering these initial questions, the team was able to better define what type of solutions they needed.



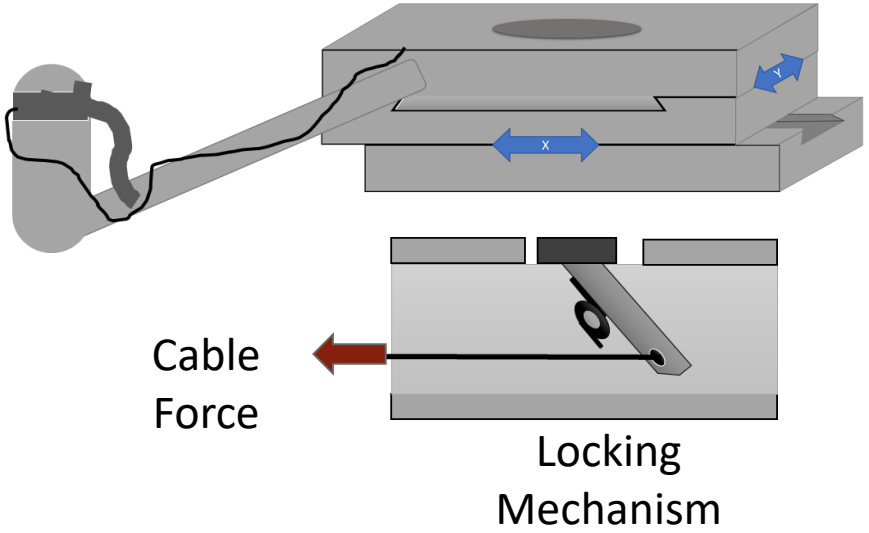
Discrete movement in all directions and angles

Free adjustment using hands to position module all at once.

The team then generated concepts based on their refined requirements – they needed an adjustable interface.

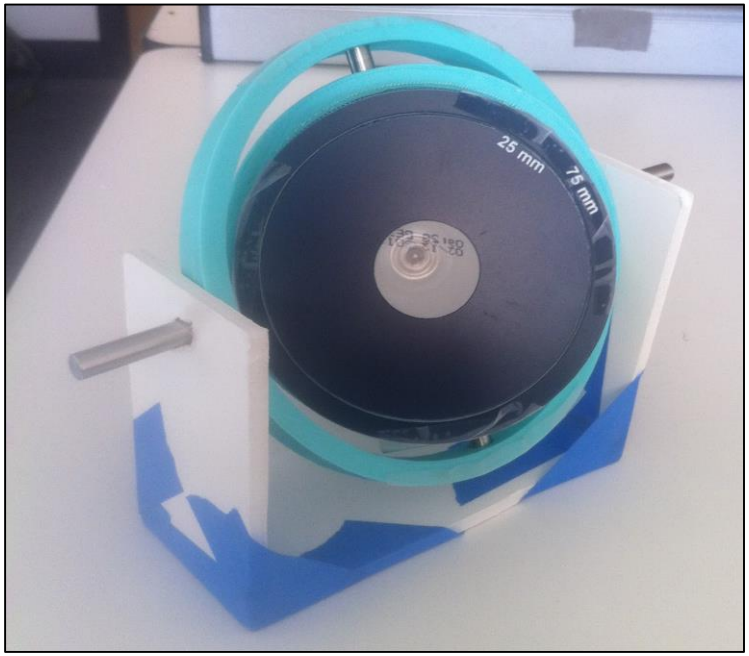


Cable brake to lock/unlock ball joint



Combination of discrete movements and free adjustment

The team then tested their gimbal design (sub-system) in the two most promising configurations.

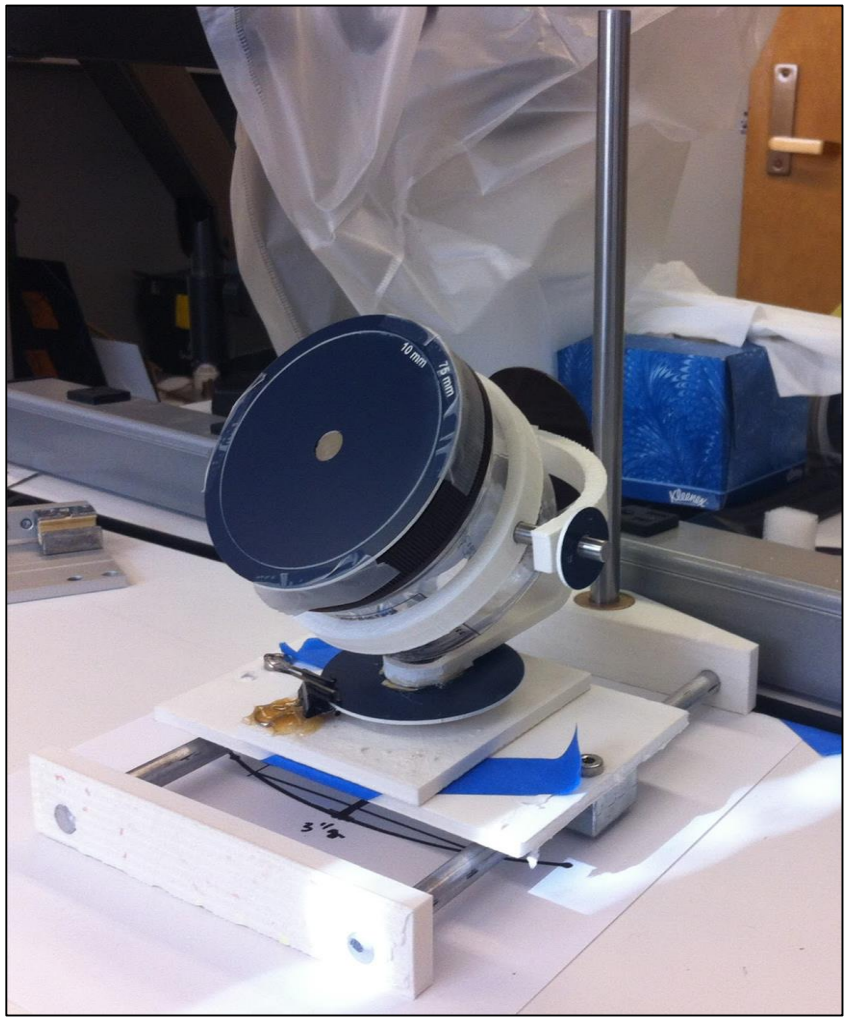


Gimbal w/ Concentric Rings

VS

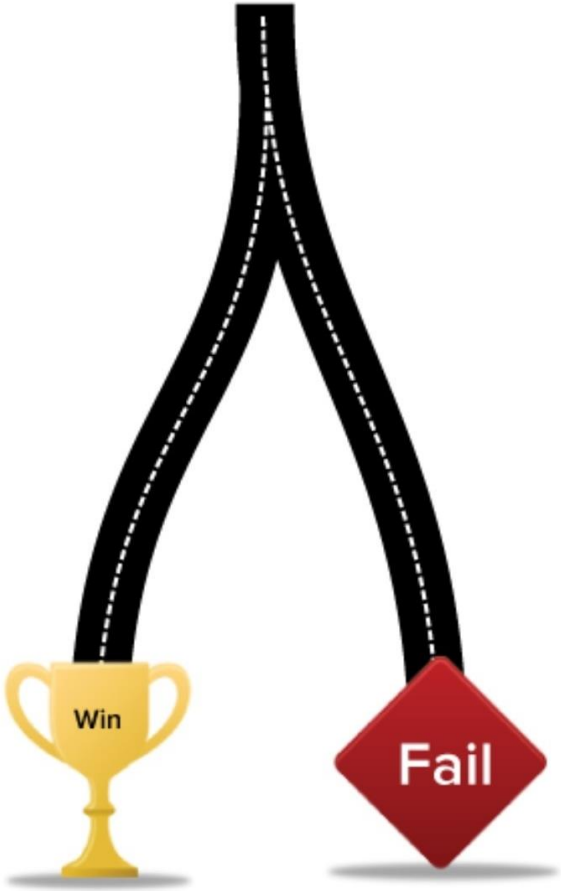
Gimbal w/ Partial Rings

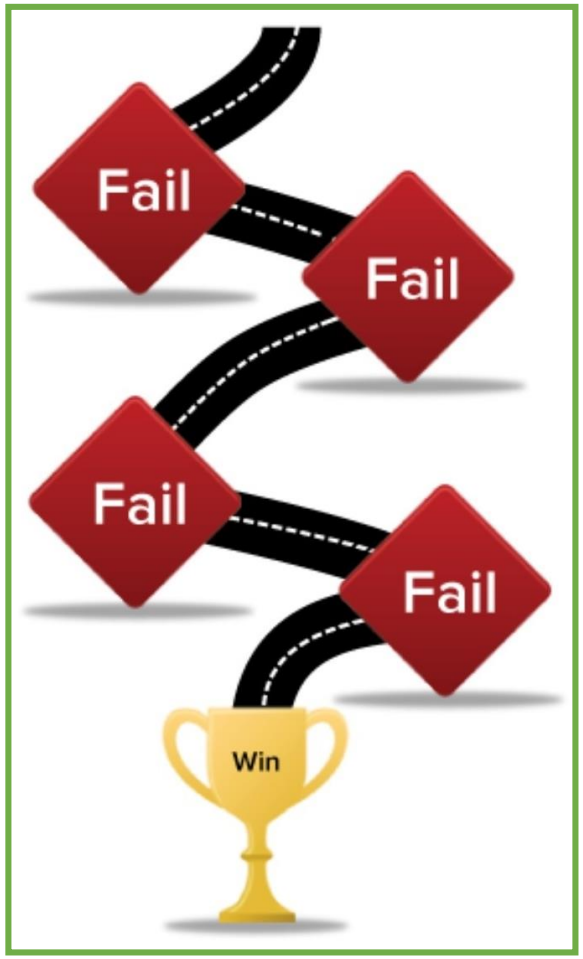
The team then tested the full system, which includes the improved gimbal design.



All of the ‘pretotypes’ and prototypes were critical in designing the right solution for the client.

So, what stops people from prototyping?

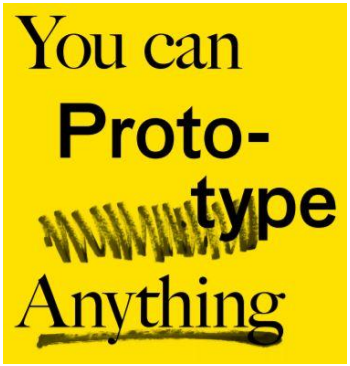




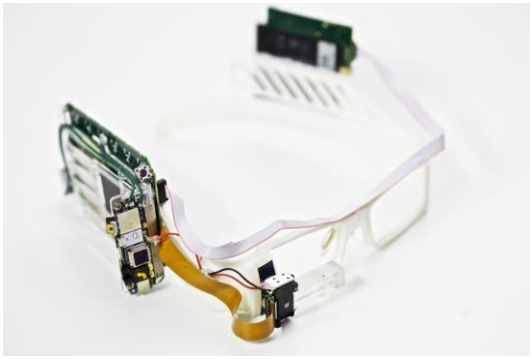
- Fear of failure
- Fear of not being “perfect” or finalized
- Fear of judgement from others, including project manager, client, or mentor
- Lack of knowledge about prototyping tools/mindsets
- Lack of prototyping culture

In summary, you should make many *purposeful* prototypes throughout the entire design process.

More prototyping resources available online, such as:



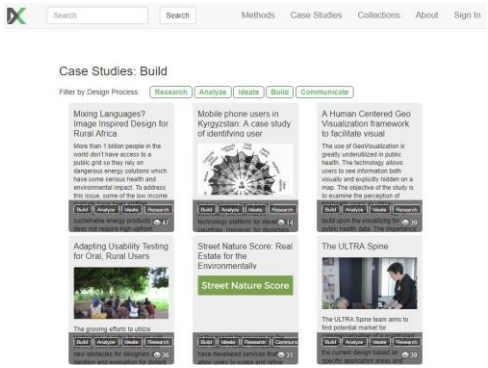
Zine booklet from IDEO



Rapid prototyping video, Tom Chi on TED-Ed

Prototyping course on Lynda by frog design

Pretotype it booklet



The Design Exchange

ACUMEN+ IDEO.org Prototyping course

First individual activity: Prototyping Canvas

…map out all assumptions and questions about your project, stakeholders, and similar solutions. Then, create a plan to build, test, and iterate on the prototypes.

Prototyping Canvas: Building Minimal Viable Prototypes

You can prototype products, processes, experiences… You can prototype components, sub-systems, entire solutions…

Problem Statement:

	Assumptions	Questions
Desirability (human aspects)		
Feasibility (technical aspects)		
Viability (business aspects)		

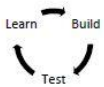
Benchmark & Reverse Engineer

What are similar solutions to your problem?
How can you learn and improve from them?

Identify All Stakeholders

End-users, consumers, client, manufacturer, maintenance, etc

Building Minimal Viable Prototype (MVP)



What is the simplest way to test your assumptions and questions?
What mediums can you use (digital, physical)? What level of fidelity should the prototype be?
Can you use/alter similar solutions for the prototype?

Testing Plan

Who is required for testing?

Where and when will you test?

How will you test/validate your assumptions and questions?

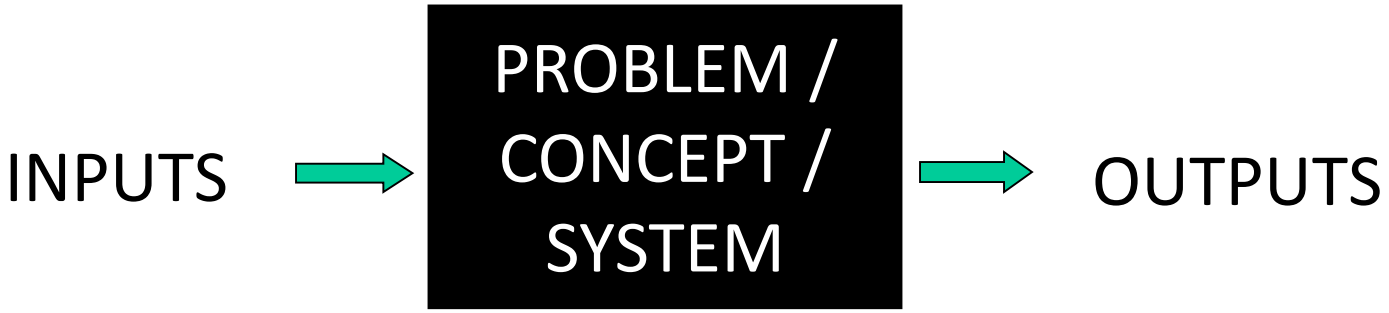
How will you measure and document findings?

Lessons Learned: Plan for next iteration

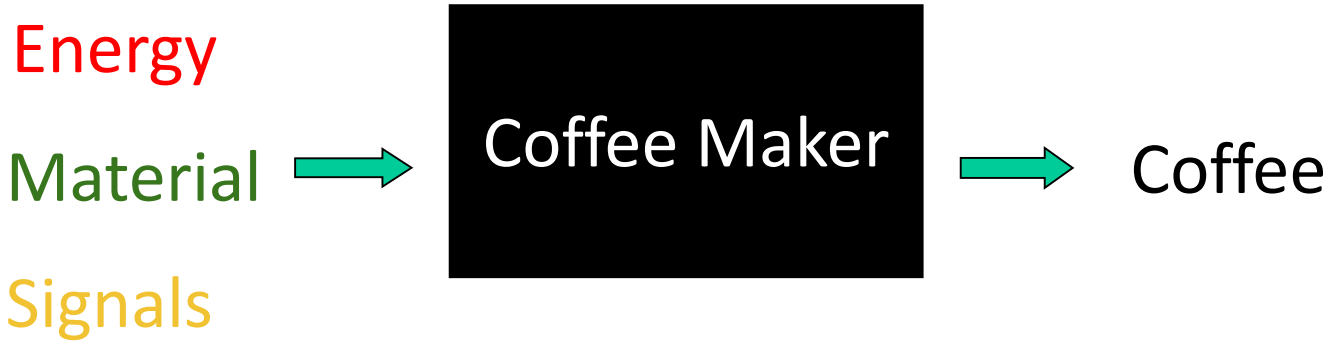
Document and distill lessons learned. What questions do you still need answered?

***You can use black boxes, functional decomposition, and mind-mapping to help you narrow down your problem/product into smaller portions. See next four slides for help.**

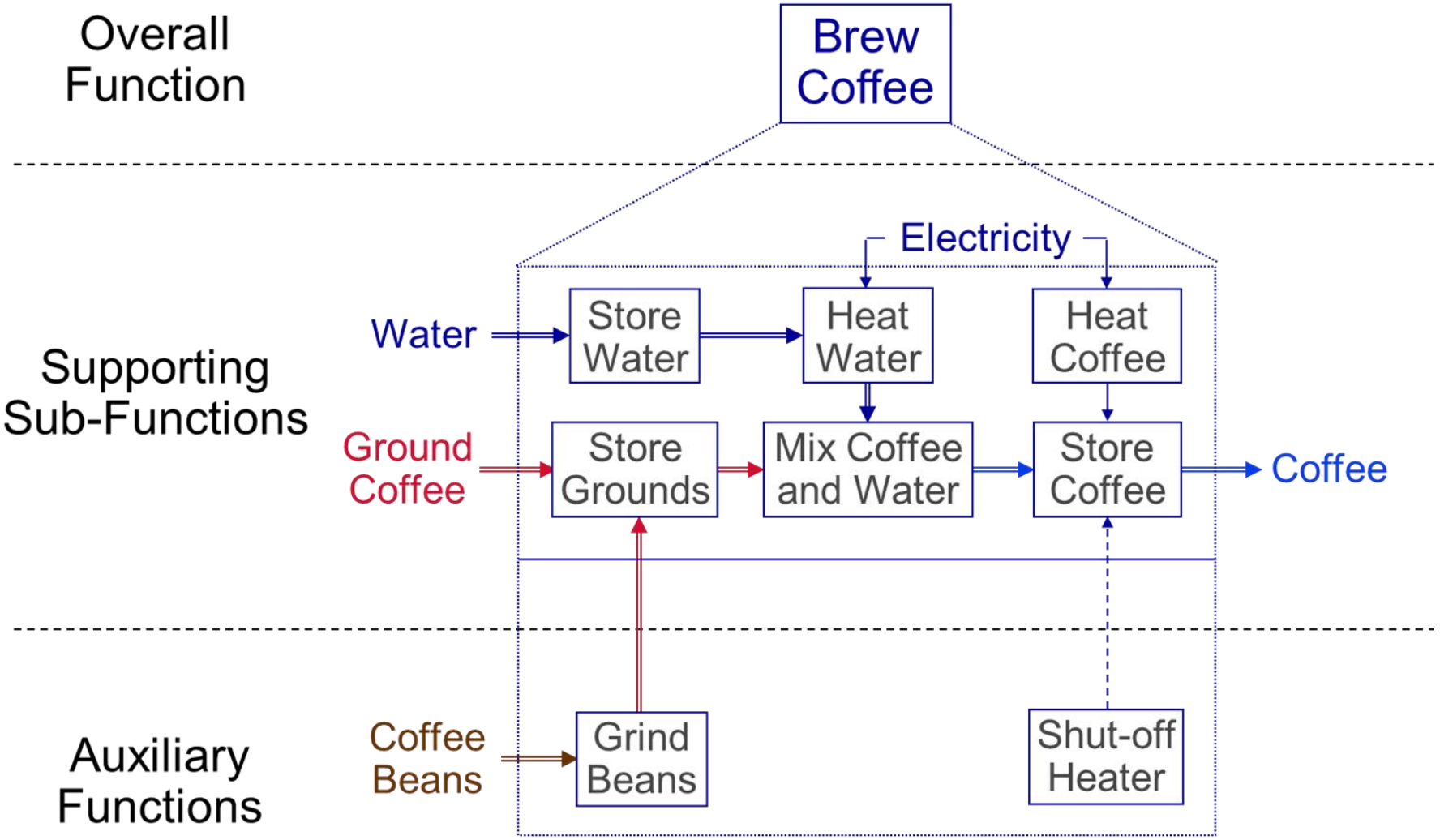
Black boxes are a method
for identifying key aspects of your design



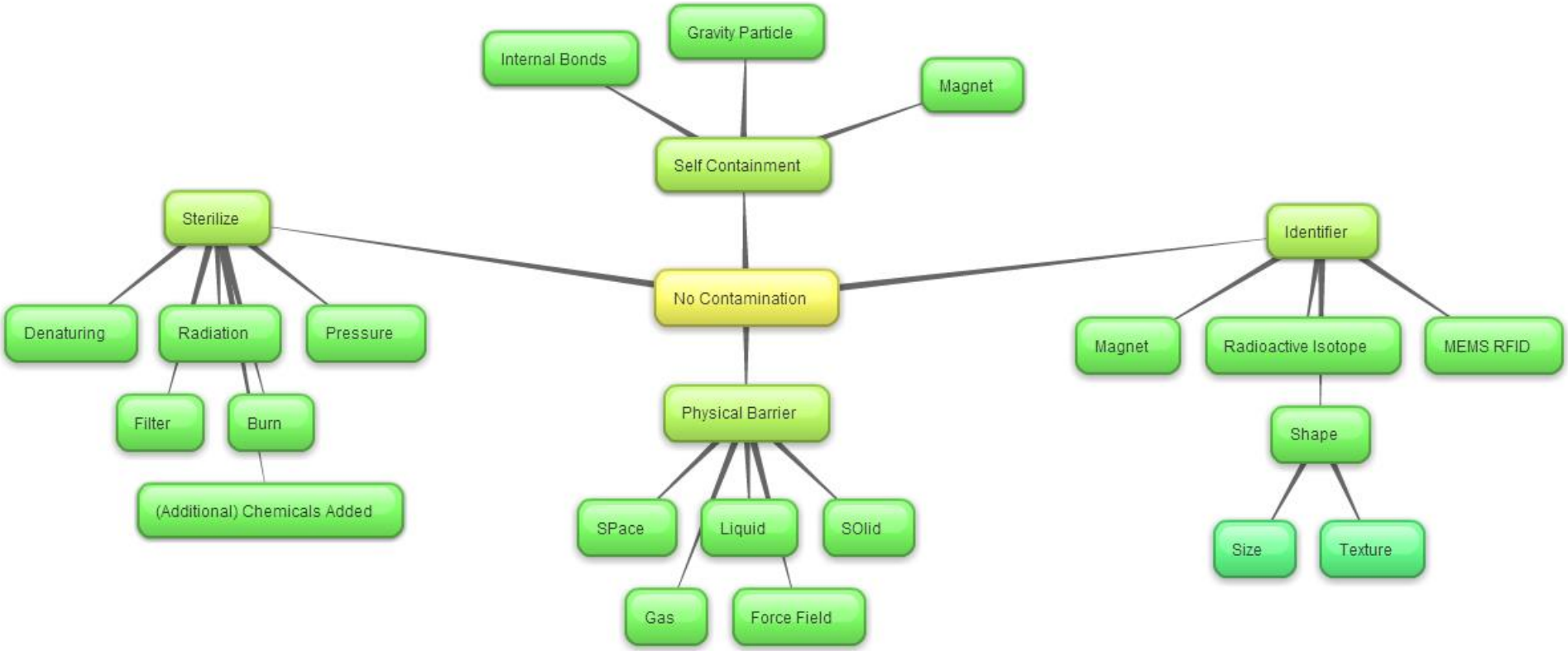
Black boxes are a method for identifying key aspects of your design



Functional decomposition is a method for identifying key functions of your design

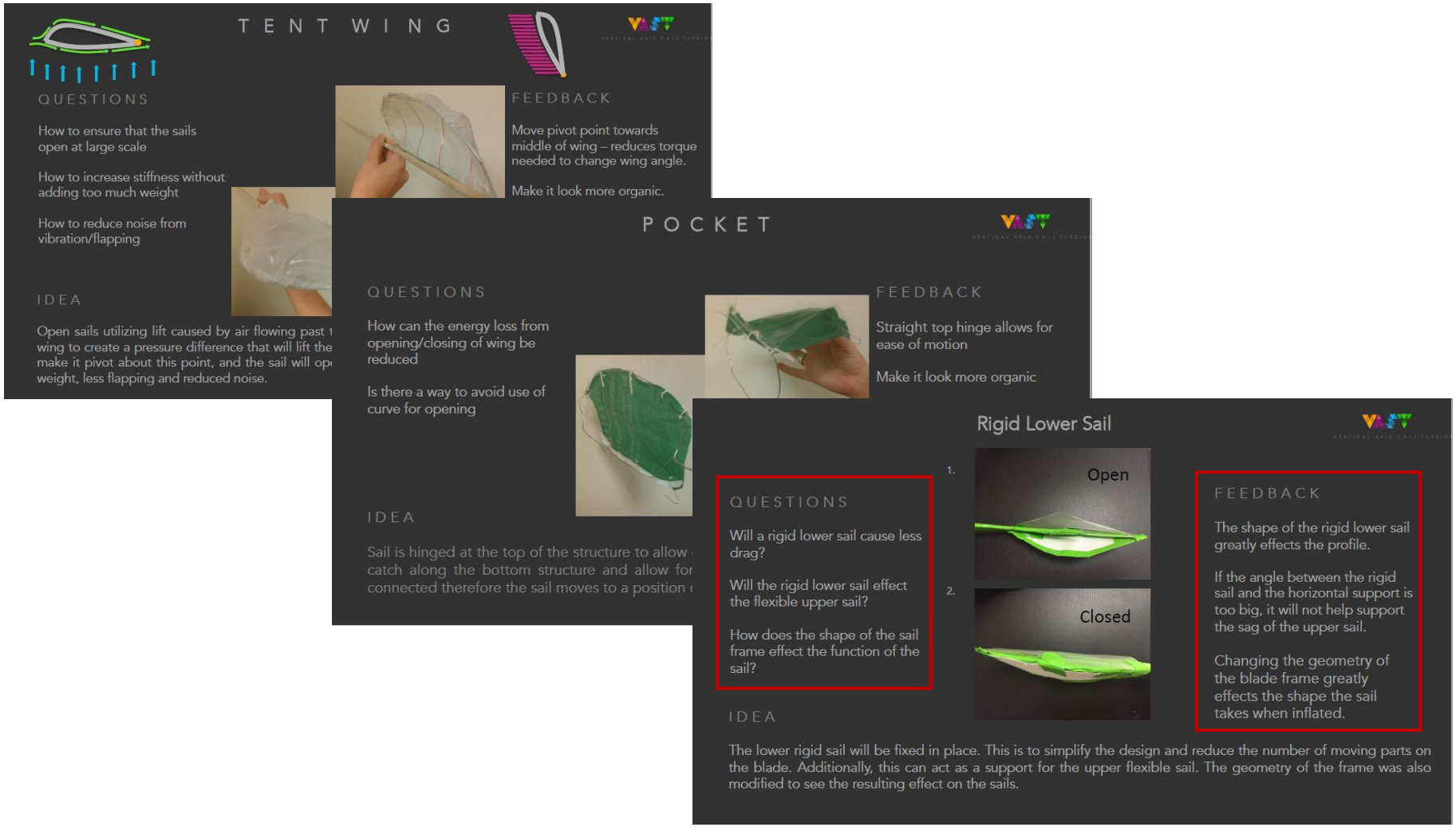


Mind mapping is a method
for breaking down problems and requirements



Second team activity: Plan to build three ‘preto-types’

…use the prototyping canvas to create a plan to build and test three prototypes. Document the process: including pictures of the prototypes with short descriptions, and the questions asked and feedback gained (example shown below).



Another example using prototypes throughout the entire design process: improving the design of a soldering iron

Prototyping is used early in the process to better understand the needs and specifications for the project.

(1) Improved Fixture

(2) Mobile Fixture

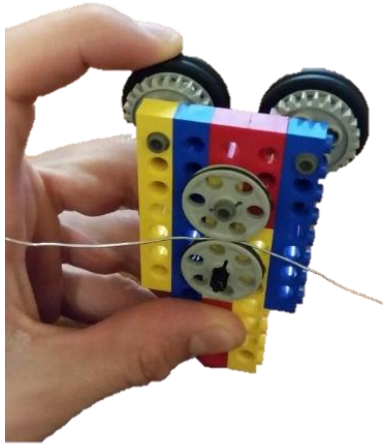
(3) Extruding Iron

Prototyping can be used during concept generation to increase ideas as well as refine solutions.

(1) Feeding in Solder

(2) Hand grip

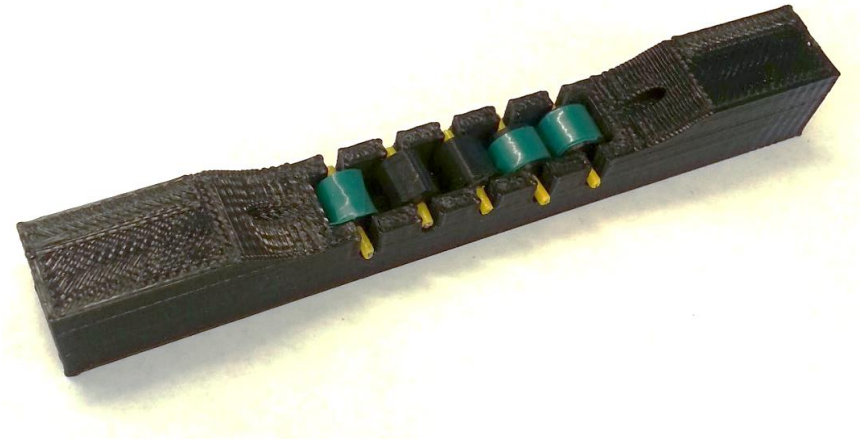
Prototyping can be used during concept generation to increase ideas as well as refine solutions.



(1) Feeding in Solder

(2) Hand grip

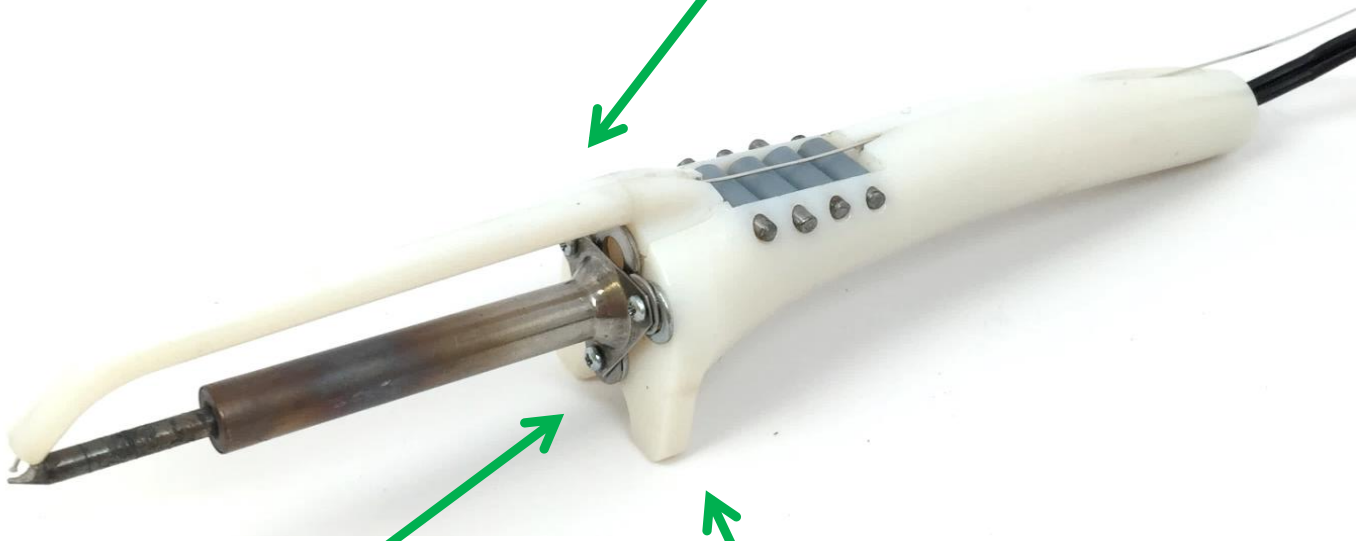
Prototyping can be used during concept refinement to improve both sub-systems and full systems.



(1) Feeding in Solder

(2) Feeding Solder + Hand grip

All of these prototypes created throughout the *entire design process* impact the final design.



All of these prototypes created throughout the *entire design process* impact the final design.