

DESIGNING *THE DUSTPAN*

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TEAM G1

DESIGN CHALLENGE

Our team was responsible for **designing, constructing, and programming** an independent **claw retrieval system**.

We used the Engineering Design Process by emphasizing stage 5: Developing and Testing the solution.

The project combines computer programming with an **Arduino-compatible microcontroller** that interfaces with a **sonar sensor** and **servo motor**

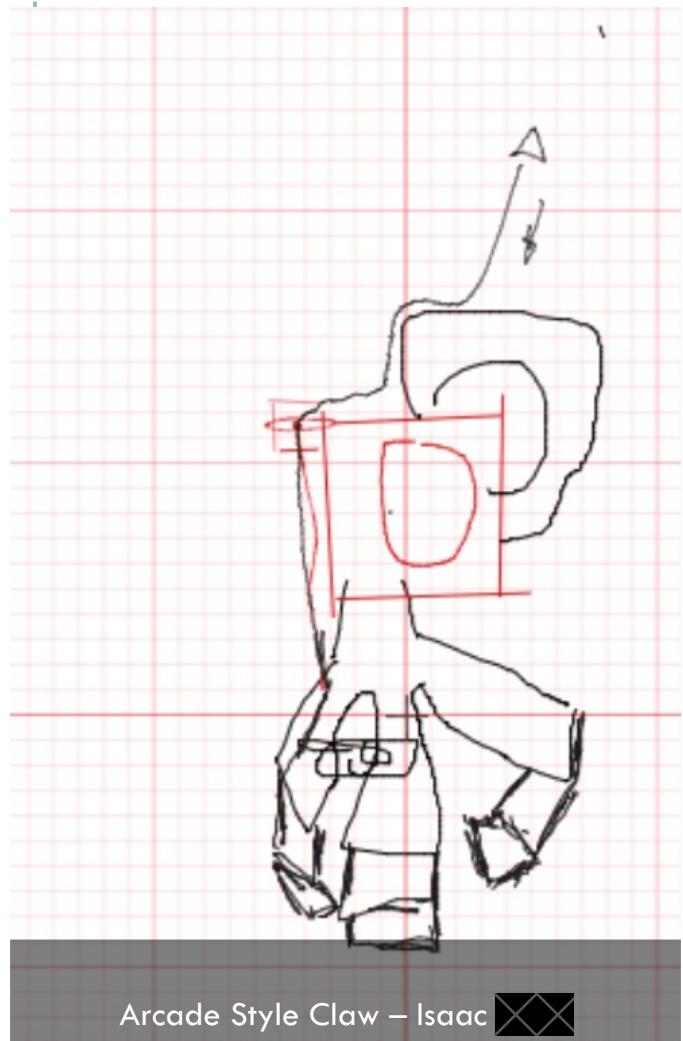
STATEMENT OF TEAM STRATEGY

Our team strategy was to **diversify the claw designs:**

Different variations of a similar layout.

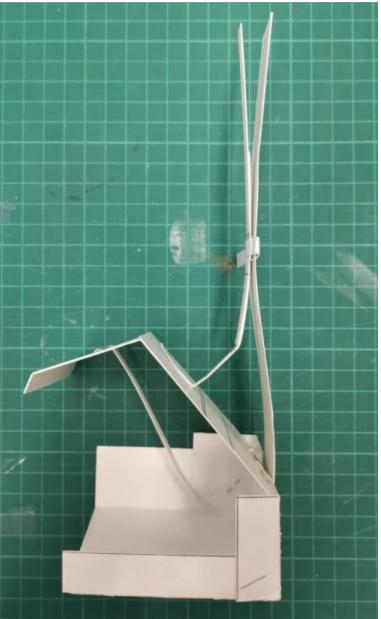
Some unique ideas (no sonar, 4-way claw)

The combination of different variations allowed us to **explore different benefits**, while ensuring the frame was **reliable** and dependable.



PROMISING CONCEPTS:
C-SKETCH ROUND

SELECTION OF PROTOTYPES



KEY TECHNICAL RISKS

External	Preventable	Strategic
<p>The servo or Arduino fails to run.</p> <p>There are bugs in the Arduino code.</p> <p>The cardboard softens due to humid weather.</p>	<p>Cardboard used delaminates itself.</p> <p>Failure of tape adhesion points.</p> <p>The pins fall out of the Arduino holes.</p>	<p>Weaker tapes / adhesives are used to save time needed for glue to dry.</p> <p>Rubber bands are used hold parts to save time but deforms the cardboard and loosens over time.</p>

RISK MATRIX

- Identify key risks that we would prioritize addressing.
- **Risk matrix score < 4** , risks monitored, and no action will be taken
- **Risk matrix score ≥ 4** risks analyzed by way of experiment, and mitigation strategies considered.

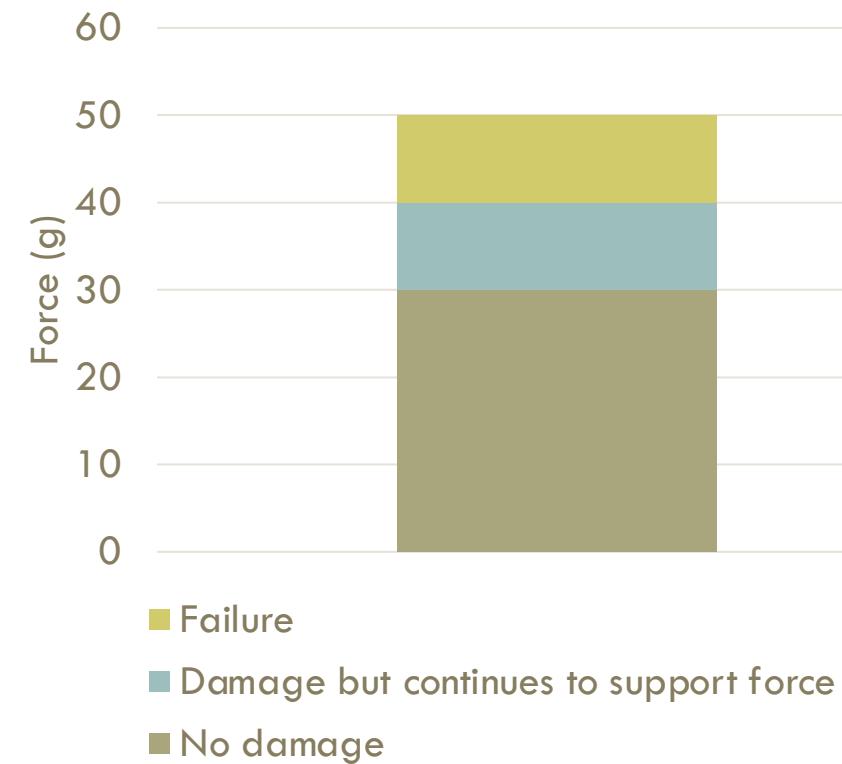
		Risk Severity			
		1	2	3	4
Risk Likelihood	1	1	2	3 Claw is mistakenly discarded Power Outage	4
	2	2	4	6 Rubber bands drop parts from claw	8 Wire detachment
	3	3	6 Coding bugs	9 Card delamination Arduino Failure Tape/Glue failure	12
	4	4	8	12	16

EXPERIMENT 1: DELAMINATION

Outline

- Card is cut and bent into a rectangular beam with dimensions 2x2x10 cm.
- It is attached to a scale with double sided tape and pulled, until **cardboard delaminates**.
- The maximum force is measured with a scale.

Results



EXPERIMENT 1: ANALYSIS AND MITIGATION

Risk Mitigation: All cardboard beams were taped completely around the beam where it is attached to another part, as forces on the claw were too great to ignore.

Reidentification: This led to poor adhesion of double-sided tape.

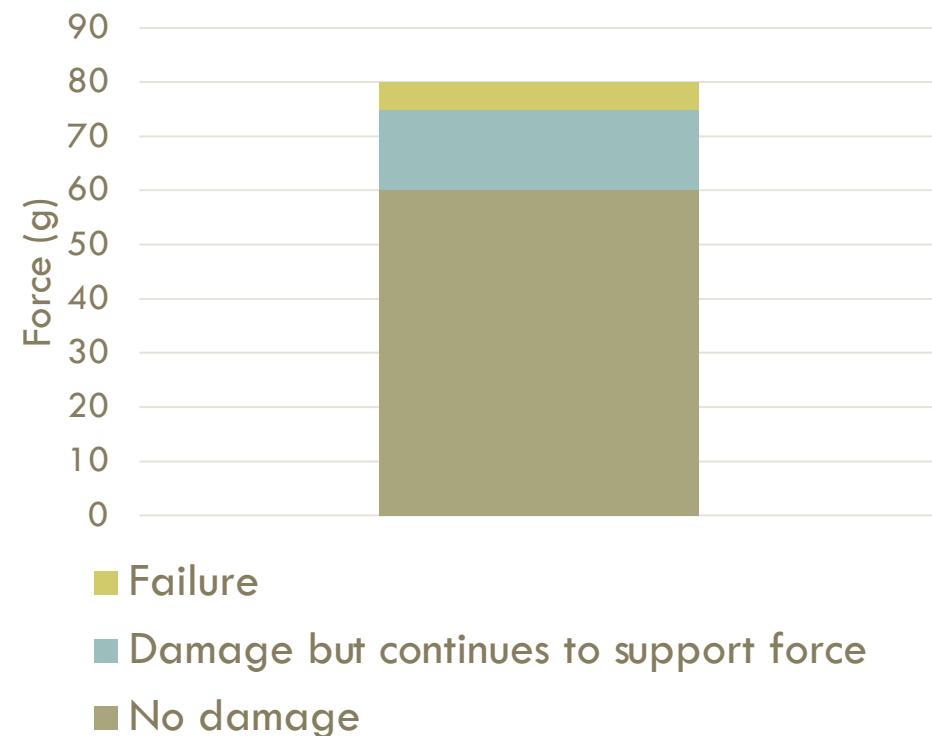
Leads to experiment 2.

EXPERIMENT 2: POOR ADHESION

Outline

- Card is cut and bent into a rectangular beam with dimensions 2x2x10 cm.
- It is attached to a scale with double sided tape (2x2 cm) and pulled **the tape falls off**.
- The maximum force is measured with a scale.

Results



EXPERIMENT 2: ANALYSIS AND MITIGATION

Risk Mitigation: A stronger double-sided tape was selected, since the claw would face higher forces than the experimental values. We could not ignore this risk.

Risk re-identification: No new risks were identified.

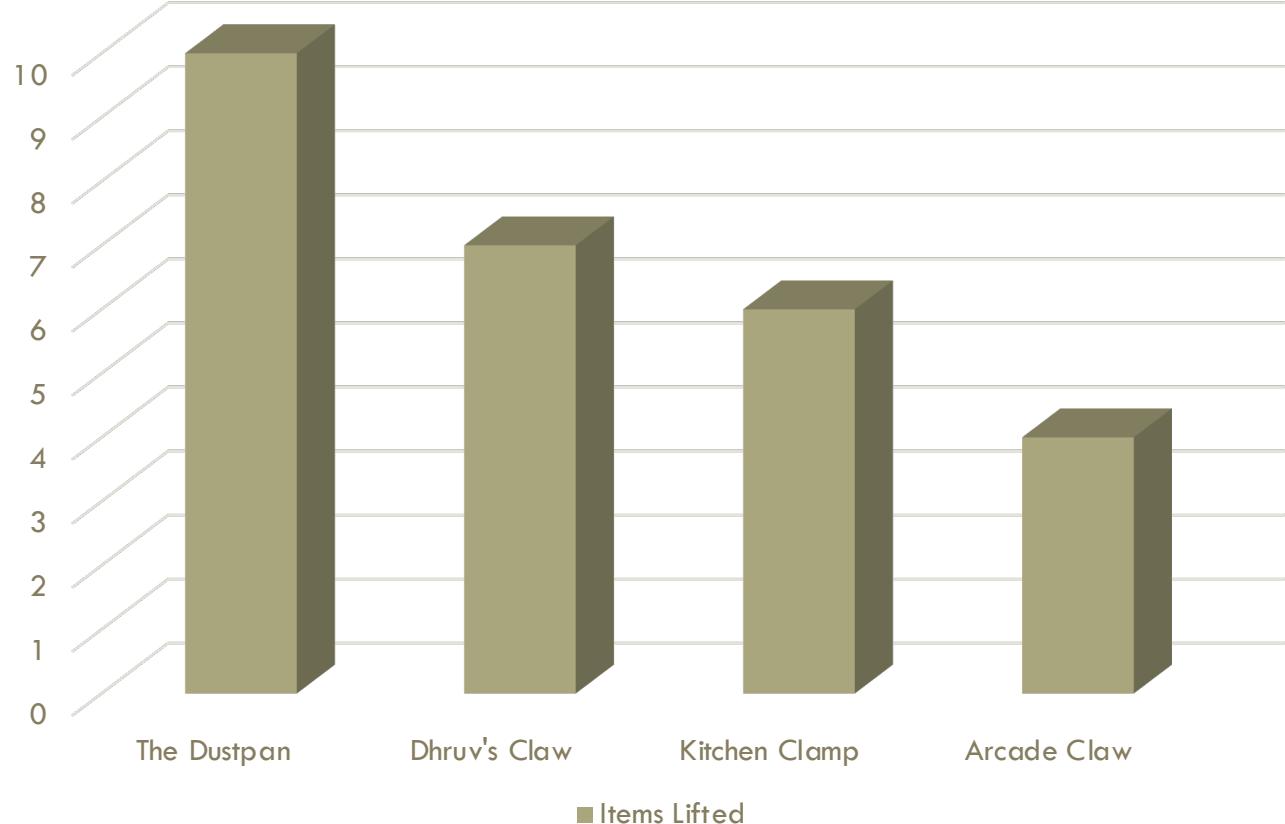
NON-TECHNICAL RISKS

	Risk Source			
		External	Preventable	Strategic
Risk Category	Safety	Natural disasters destroy claw environment	The claw is too strong and crushes fingers.	N/A
	Project Management	The person who runs the claw has a 3-hour lab before and might be late. The family throws away the claw by accident Team members cannot build claws due to the home kit being late Team member gets covid-19	Some team members cannot make the claw because of several midterms the week before. Some team members are unable to build a claw because of lack of expertise/experience.	Only one person focuses on their claw to save time.
		The operator has a shaky hand and is unable to lower the claw onto the object The string catches onto external objects and is disabled.	Wires may detach from the Arduino if handled roughly. The claw will spin around uncontrollably while lowering the claw There is a power outage and operator cannot power the claw Operator destroys claw by accident (e.g., spilling water, dropping too hard, etc.)	The claw will break itself if used on heavy objects first / often
	Operational			

CHOOSING THE BEST CLAW

- We held a pre-competition to attempt items used the competition
- The Dustpan **lifted** the most items successfully
- We selected The Dustpan

Items successfully lifted by each claw



SUMMARY OF PROMISING CLAWS

The Dustpan

Broad base allows to capture a variety of objects.

Fast closing allows even the heavier objects to be picked up

Uses mainly cardboard and tape (easily reproducible).

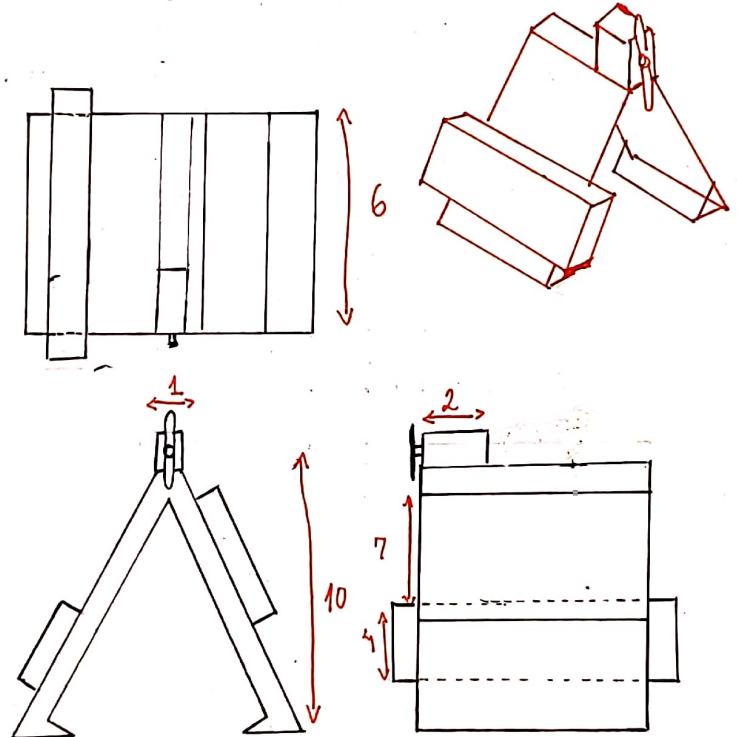
Dhruv's Claw

Smaller in size –highly specialized for small objects.

Absence of sonar sensor allowed group to experiment with different ways of programming.

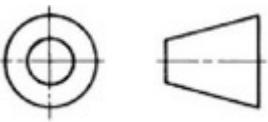
Easy to carry around.

Is 100% automatic.



Units in cm

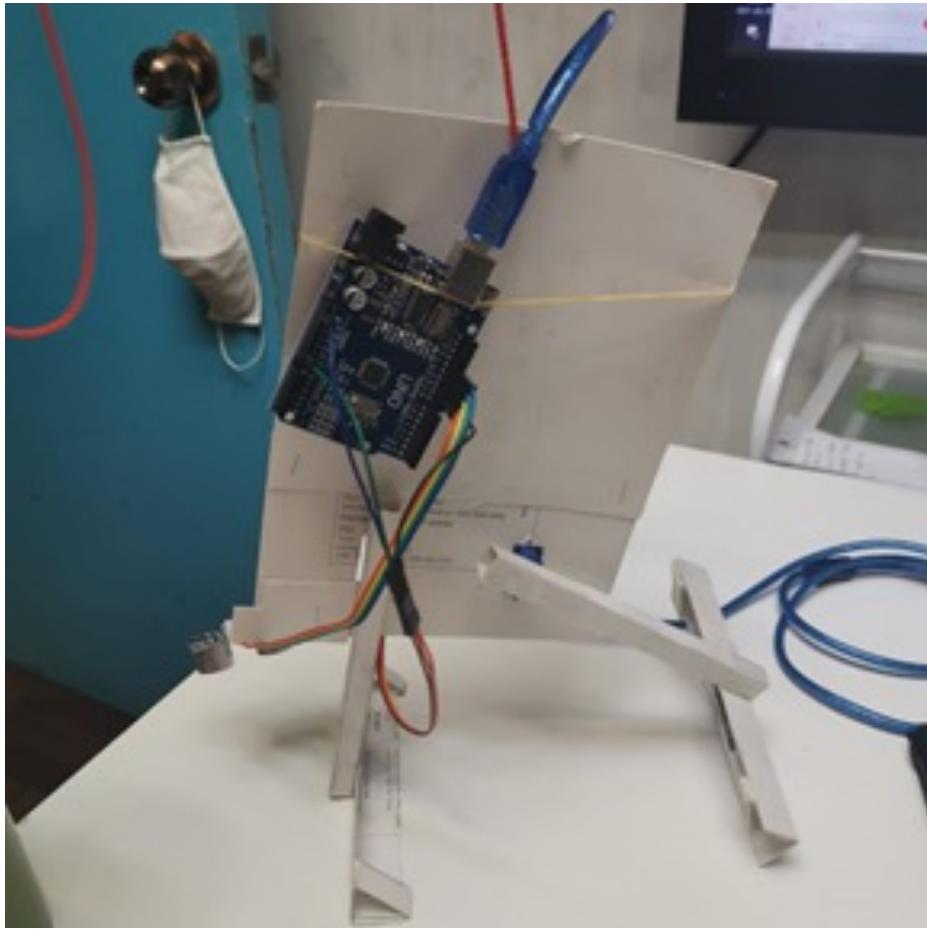
Dhruv's Claw – Drawing by Laura



DHRUV'S CLAW

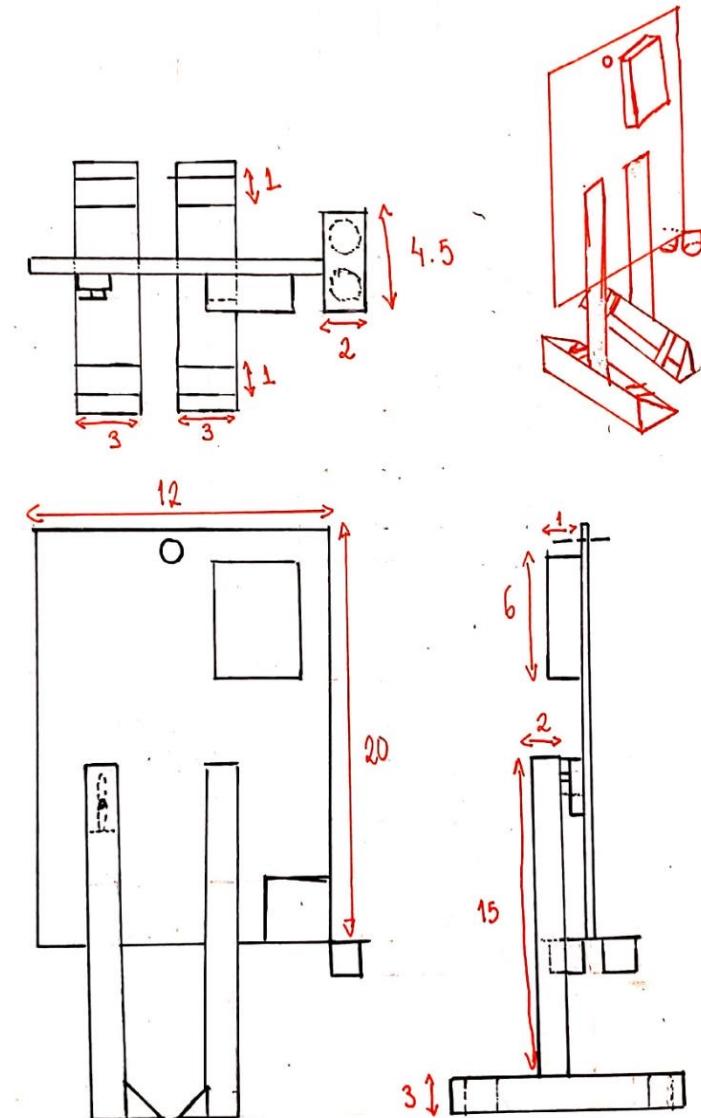
Final Design – Engineering Drawing and Final Design





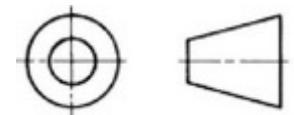
THE DUSTPAN

Final Design – Engineering Drawing and Final Design



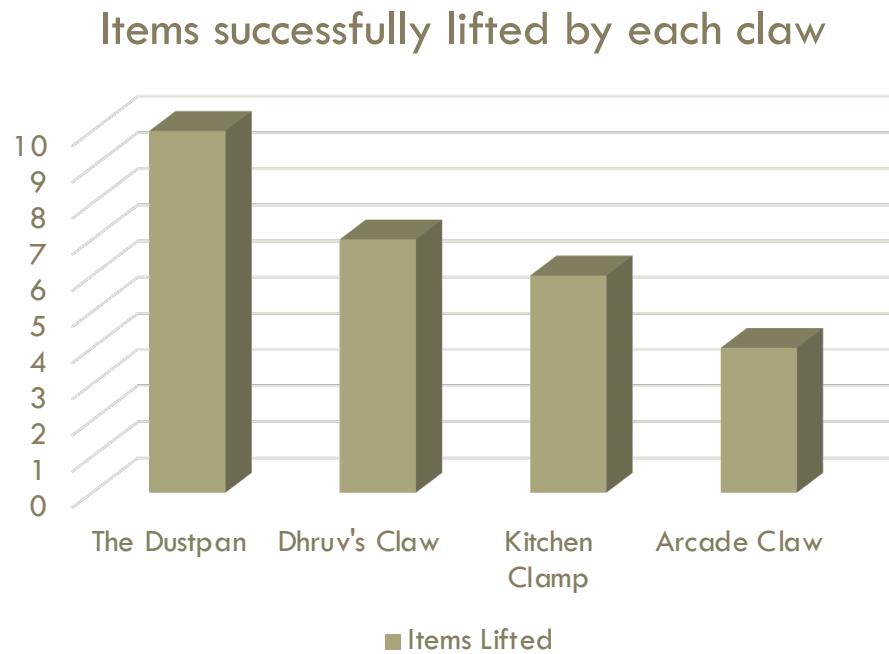
Units in cm

Dustpan – Drawing by Laura

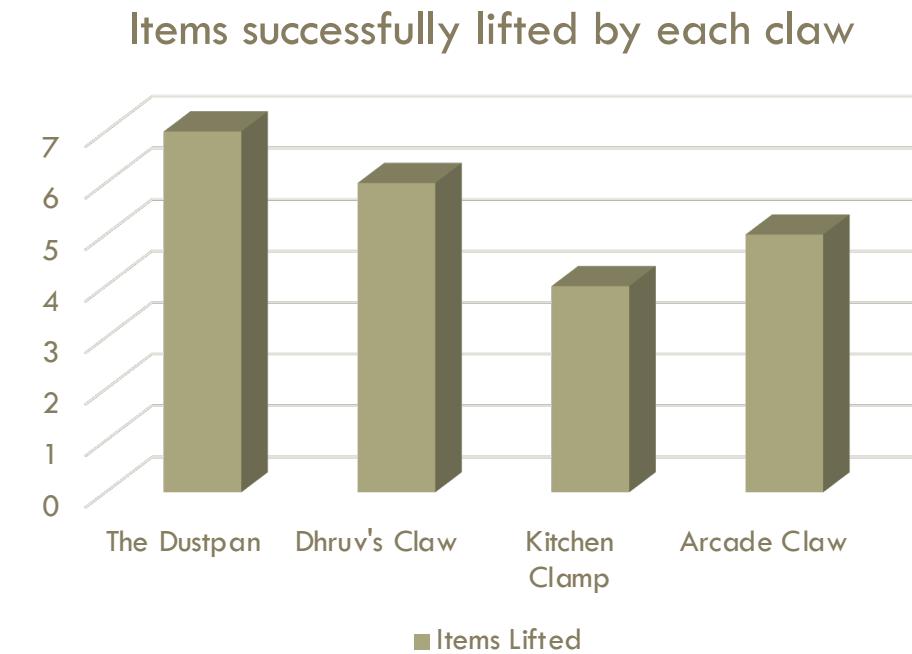


COMPARING PERFORMANCE

Estimated



Actual



- Overall rank mostly the same (3rd and 4th place switched)
- Scores generally lower due to operator anxiety and time constraints.

DOING THINGS DIFFERENTLY

First claw idea would have been a great first iteration or prototype.

Prototyping highlighted common errors, and improvements which could have been implemented in a second iteration of the c-sketch

The material used could have potentially been reinforced using a glue-like solution to aid the carrying of heavier objects such as the soda can.

The servo motor could have been placed more efficiently to facilitate a greater force generated when the claw is in operational claw design.

CONTRIBUTIONS

1. Statement of design challenge – Bella
2. Statement of team strategy – Isaac
3. Summary of Promising Concepts - Isaac
4. Engineering Drawings - Laura
5. Selection of Prototypes we Built - Kenny
6. Summary of Key Technical Risks – Paco
7. Risk Matrix – Paco
8. Experiment. 1 - Paco
9. Experiment. 1 - Paco
10. Experiment. 2 - Paco
11. Experiment. 2 – Paco
12. Summary of non-technical risk – Paco
13. Choosing the Best Claw – Paco
14. Summary of Promising Concepts –
Laura and Bella
16. Final Design Pictures – Isaac
17. Comparing initial and final
performance – Wenjia Huang
18. What we would do differently – Dhruv
19. Contributions Slide – Bella
20. Finishing Touches and Submission –
Dhruv