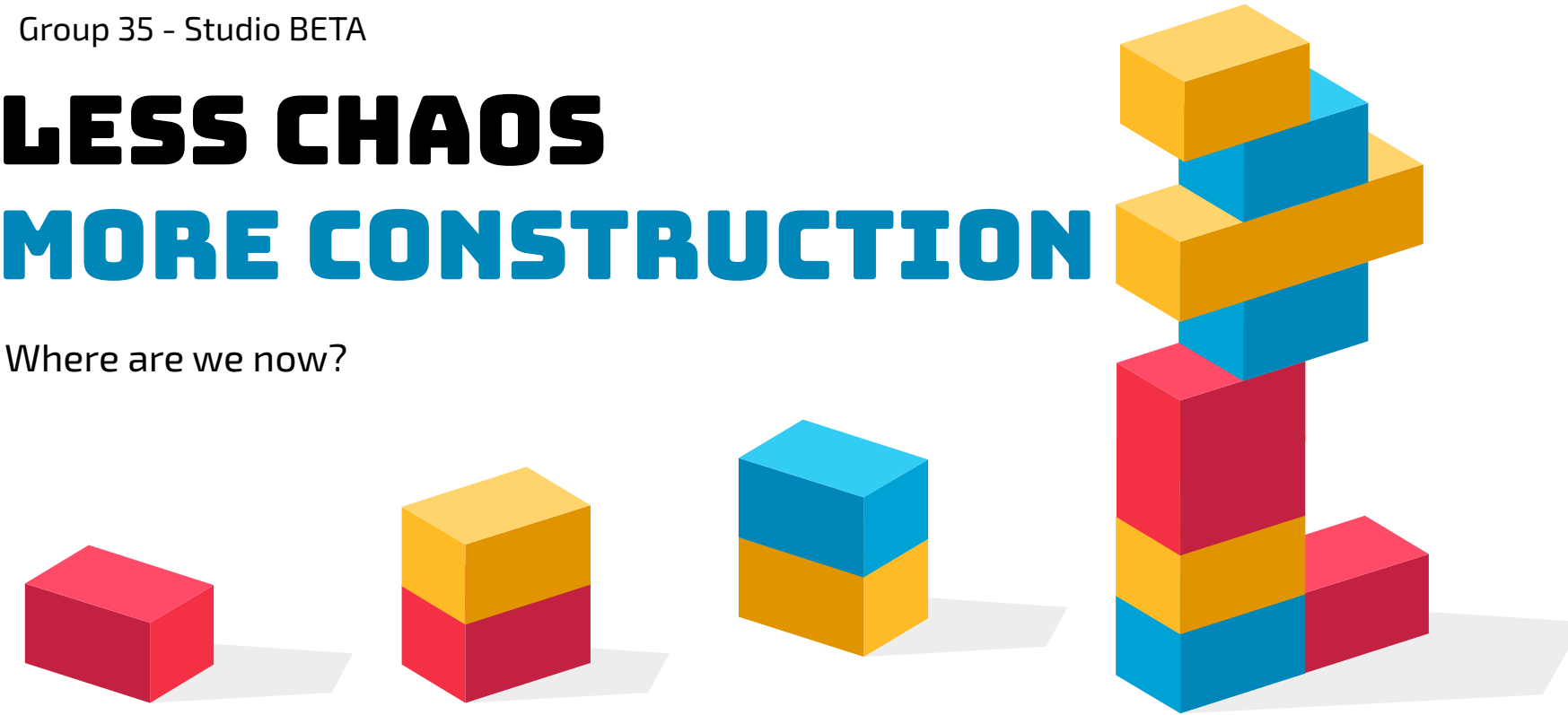
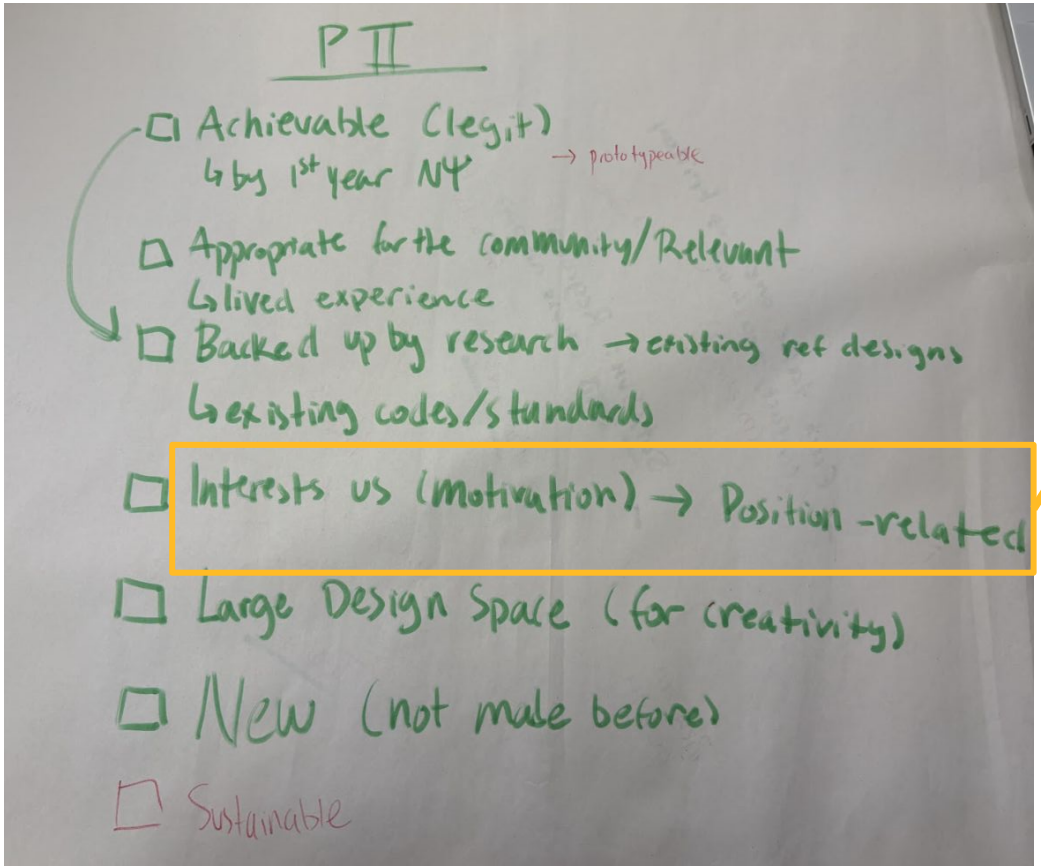
Group 35 - Studio BETA

LESS CHAOS
MORE CONSTRUCTION

Where are we now?



TEAM VALUES



From Studio 3 / 4, during discussion of "What makes a good Praxis 2 opportunity?"

TEAM VALUES:

1. Creativity
2. Collaboration
3. Inclusivity

TOROLUG VALUES:

1. Passion for creating
2. Passion for collaborating
3. Come together to connect

ToroLUG (Toronto LEGO User Group) is a vibrant community of adult LEGO enthusiasts who share a passion for building, creating, and collaborating. We come together to connect, inspire, and showcase our love for LEGO as both a hobby and a creative medium.

https://torolug.ca/about-us/

REFRAMING THE RFP

01

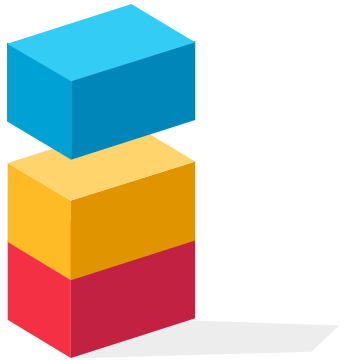
WHAT SIZE SHOULD IT BE?

According to meeting with ToroLug members, the size of the design should be smaller than 3 stacked banker boxes.

02

WHAT DOES IT SORT BY?

By size, mechanically, and an aided sorting method, through colour. As a *process*, rather than a *product*.



RESCOPING THE RFP

01

WHAT LEGOS SHOULD IT SORT?

From the MEDIUM Standard LEGO set, an official LEGO product.

02

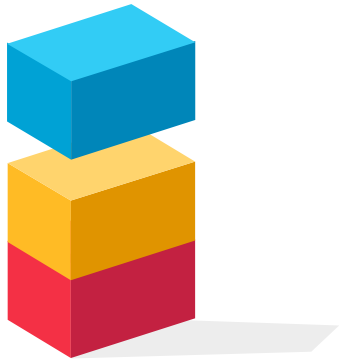
HOW SHOULD IT SORT?

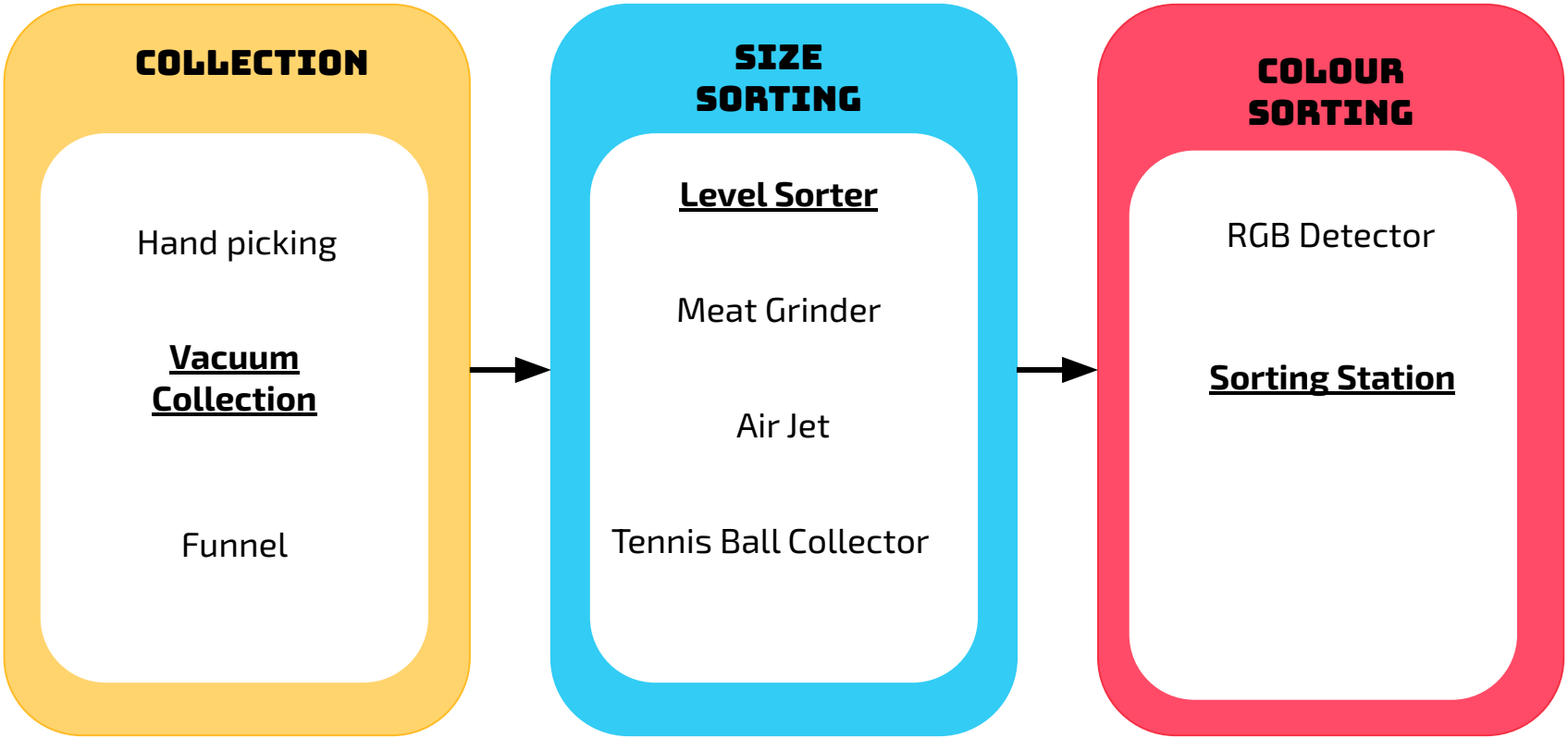
Semi or fully automatically with maximum user input of 1-2s per cycle.

03

SPECIFICS ON INTAKING LEGO

LEGO are not clumped, and enter individually.



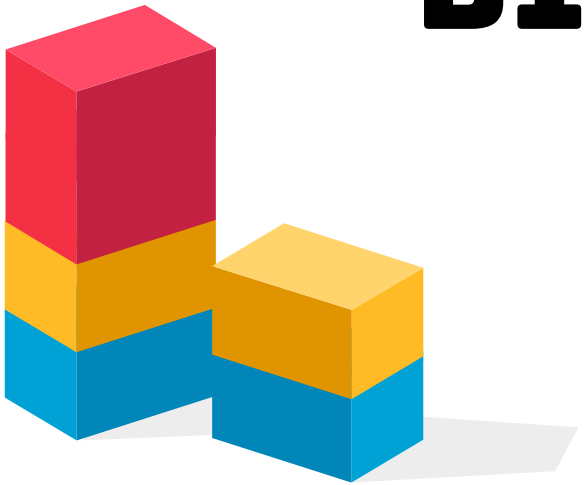

COLLECTION
Hand picking
Vacuum Collection
Funnel
SIZE SORTING
Level Sorter
Meat Grinder
Air Jet
Tennis Ball Collector
COLOUR SORTING
RGB Detector
Sorting Station

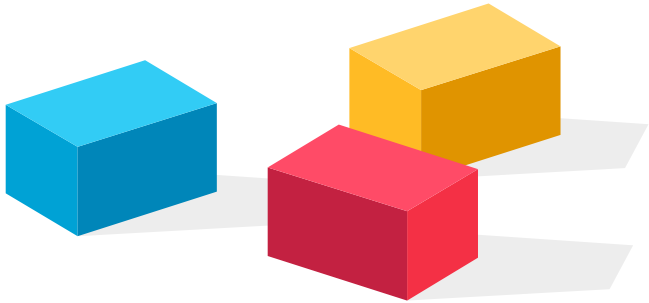
PREFERRED DESIGN

SORTING MECHANISM	WHAT IS IT?	WHY?
MECHANICAL	Level sorting	More compartmentalized sorting (**obj. 7**), while also having a large presence in the industry, improving feasibility (related to **obj. 8, obj. 9, obj. 10**)
COLOR	Aided sorting	Almost unanimous interest in something that helps them speed up *their pre-existing sorting methods* (**obj. 1**), works with their own categories (**obj. 6/obj. 7**), accuracy (**obj. 10**) and consistency (**obj. 8 and obj. 9**)

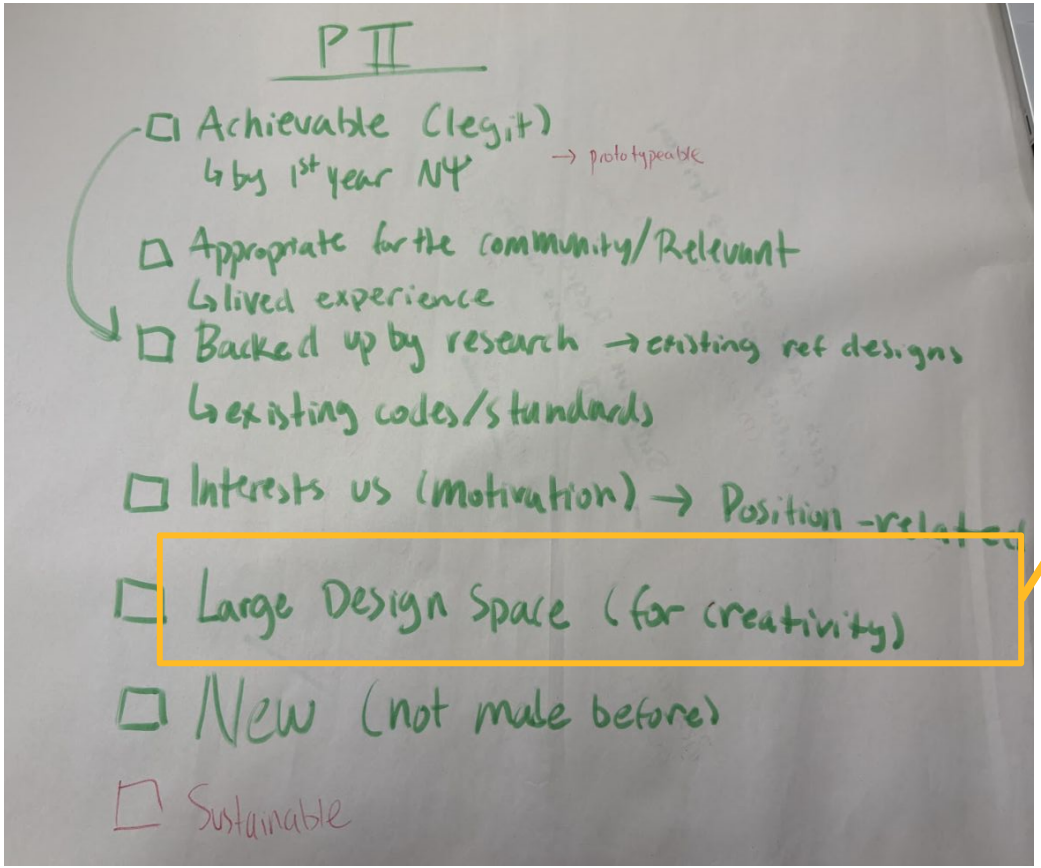
DIVERGING

Outcomes and tools





"GOOD" P2 OPPORTUNITY

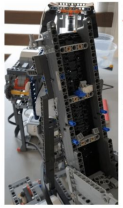


From Studio 3 / 4, during discussion of "What makes a good Praxis 2 opportunity?"

Have used 3 complete diverging tools and one informal diverging tool to **exhaust our design space** and gain a wide range of prototypes!

TOOL 0: REFERENCE DESIGNS

1. AI-sorter
https://www.streamhead.com/3d%20printing/ai/2021/11/01/deep-learning-lego-sorting.html



The LEGO sorting system, built with LEGO's EV3 Mindstorms kit and a Raspberry Pi with a camera and LED lights, accurately identifies and categorizes LEGO pieces. It uses a dual-belt system, where the first belt lifts bricks from a bin and the second aligns them for individual processing. A high-quality camera and motion detection ensure optimal positioning before capturing an image. The system then processes the images using a deep learning model with OpenCV, Keras, and TensorFlow, achieving over 95% accuracy in recognizing three brick types, with expansion plans. Once identified, bricks are sorted into one of six bins on a rotating wheel, with a Mindstorms color sensor ensuring precise placement.

2. The Mechatronics Project
https://www.instructables.com/Mechatronics-Project-Lego-Sorter/

The LEGO sorting system uses a conveyor belt with 6mm plywood supports and 3D-printed PLA rollers powered by a JGA25-370 DC motor at 120 RPM. A proximity sensor detects incoming bricks, stopping the belt so a TCS34725 color sensor can identify their color. The system then

3. Official LEGO sorting hat
https://www.lego.com/en-ca/product/talking-sorting-hat-76429

The sorting hat, like in harry potter, can efficiently sort lego bricks into categories and level of specificities according to the user's need. This design incorporates artificial intelligence and some sort of vision system. But need to add a way of sending bricks to the sorter because it only sort one brick at a time when the brick is under the hat.

4. candy sorting machine
https://techcrunch.com/2017/02/06/this-candy-sorting-machine-isnt-the-hero-the-world-wants-but-its-the-hero-the-world-needs/

The candy sorter sorts using a RGB sensor that sorts only by color and the output nozzle turns around to place the candy into the right places.

Yiran:

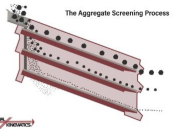
1. Automatic cleaning and sorting machine for fruits and vegetables
https://www.juiceprocessline.com/automatic-fruit-weight-classifing-machine/

Sort by weight and some measurement taken while the fruit swims through the machine. Use water flow instead of a conveyor belt to clean the fruit at the same time.

2. Automatic Stone Bead Size Sorting Machine Vibration Sieving Machine
https://gemstonemachine.com/productinfo/748682.html

Machine vibrates to allow for beads to move through levels of specificity, also slanted so that sorted beads would fall into different categories after being sorted to the correct specificity. This avoid blocks being stuck in the holes impeding other parts from being sorted when user need to sort large amount of bricks.

The Aggregate Screening Process



*similar to our morph chart, it has the tilt to push down, and it also has gratings for the lego to fall into
- Maybe add a mechanical motor at the bottom so it's mostly automated.
- Can also incorporate vacuum suction.

3. Color sorting – DIY color sorting machine, probably in same range as what we can prototype (arduino-based)

** short range, because can only really do it in these buckets
- Nice RGB sorting, can probably code to be able to customise
- Look into how we can intake larger LEGO pieces (bigger than M&Ms)

GOAL: Each find ~3 existing sorting devices and comment on its usefulness to our RFP

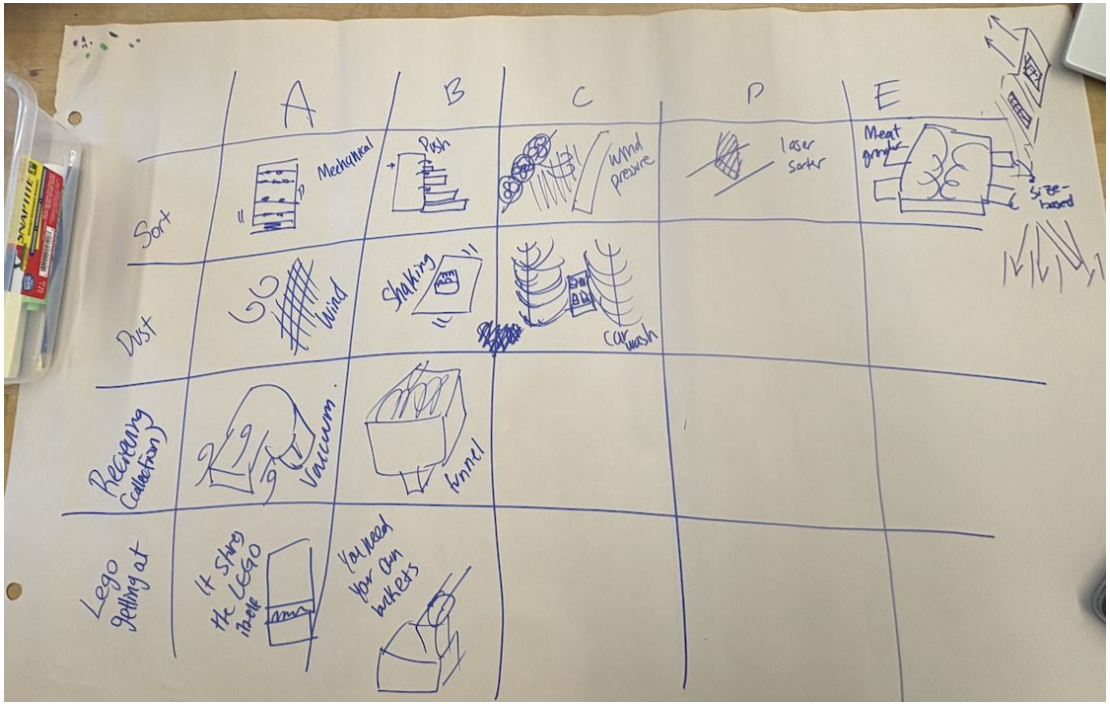
OUTCOMES:

1. Better idea of the existing industry-level sorting devices

2. Gain a better sense of the feasibility of components of our device

What can we take away from existing designs to help us?

TOOL 1: MORPH CHART



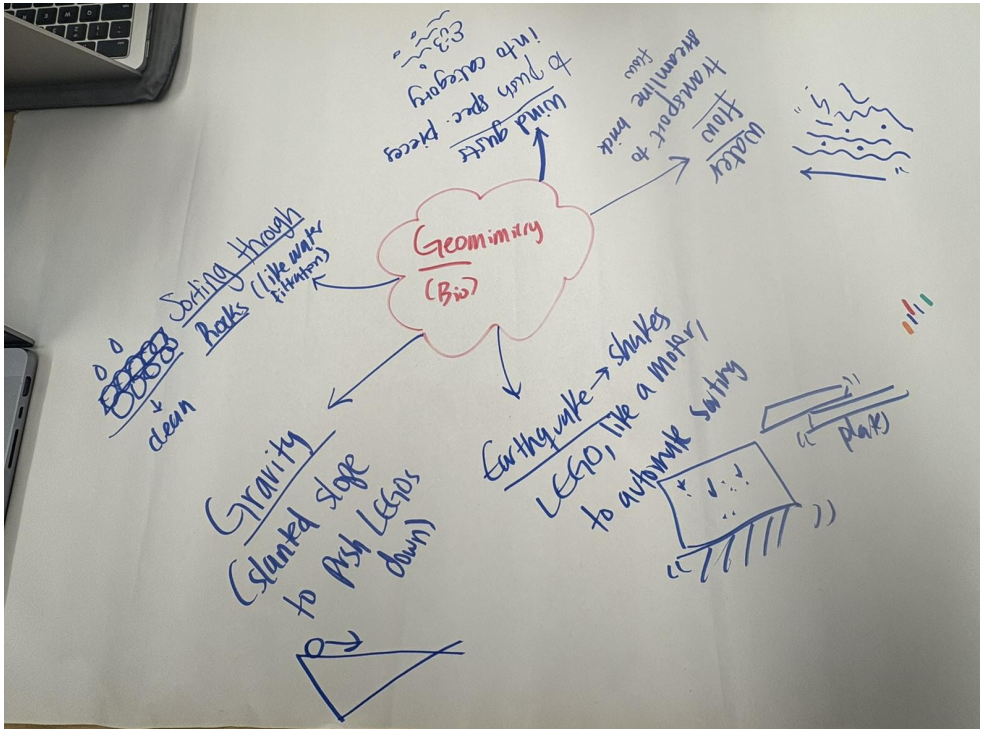
OUTCOMES:

1. Better idea of the different functions of the product

2. Got us thinking about how to combine these effectively

How can we flesh out individual components of our design?

TOOL 2: GEOMIMICRY



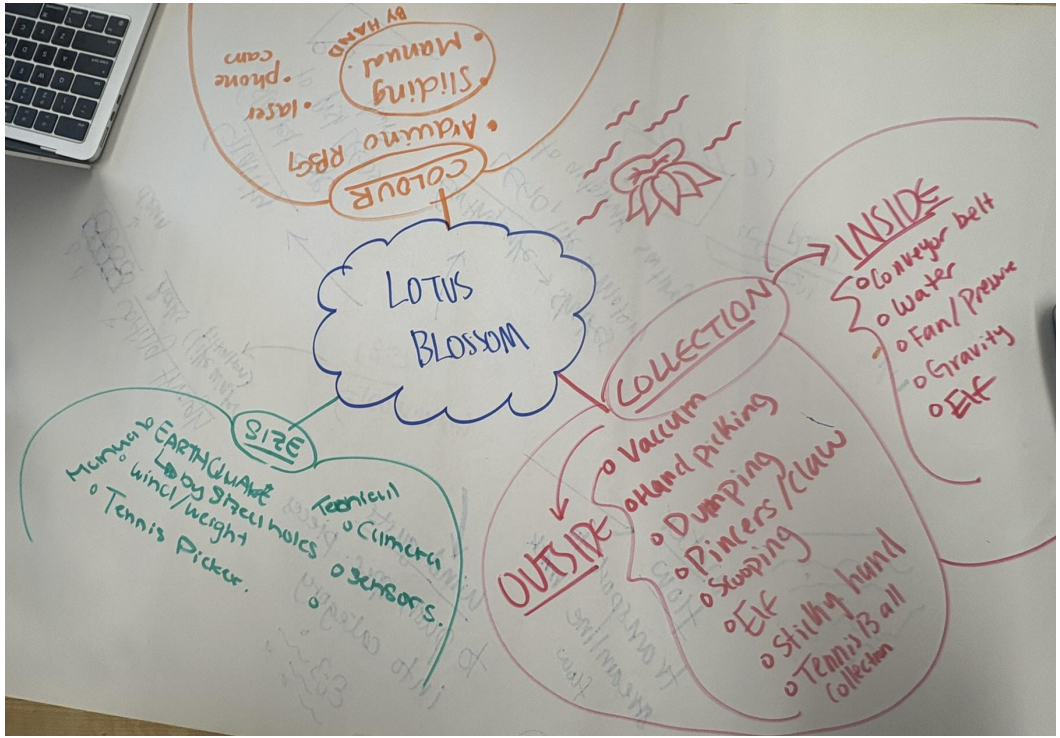
OUTCOMES:

1. Connections to real-life sorting (e.g. water filtration)

2. Connections to natural mechanisms that can help sort (e.g. gravity, earthquakes)

Maybe answers were right in front of us the whole time?

TOOL 3: LOTUS BLOSSOM



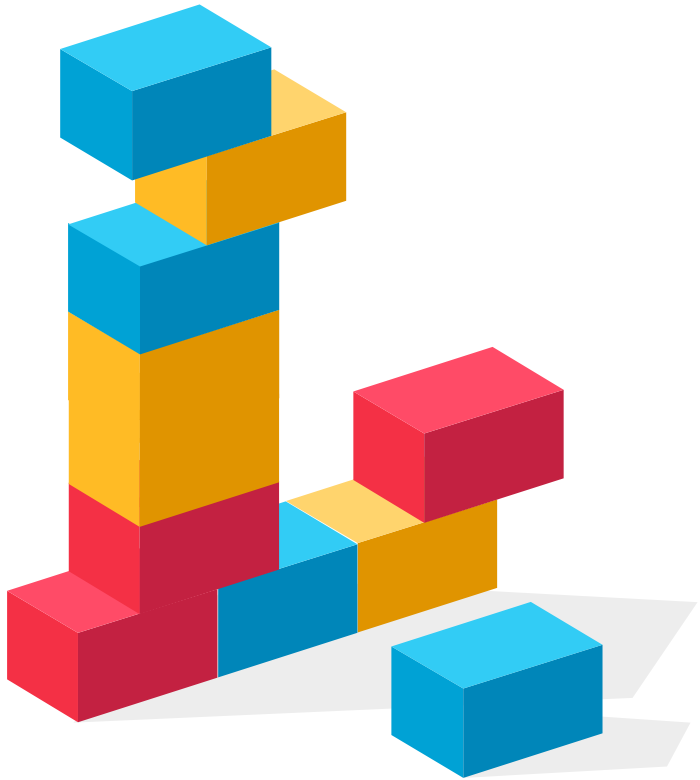
OUTCOMES:

1. Scoped our design from “product” → “process” with 3 stages

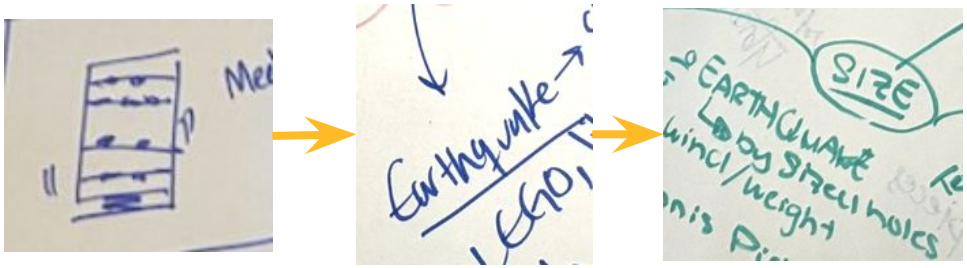
2. Helped us diverge on individual components

How are some ways we can connect these pieces together?

When we reached our third structured diverging tool, our ideas **began getting repetitive.** We mostly explored our design space, so we **began to converge** on our existing ideas.



e.g.



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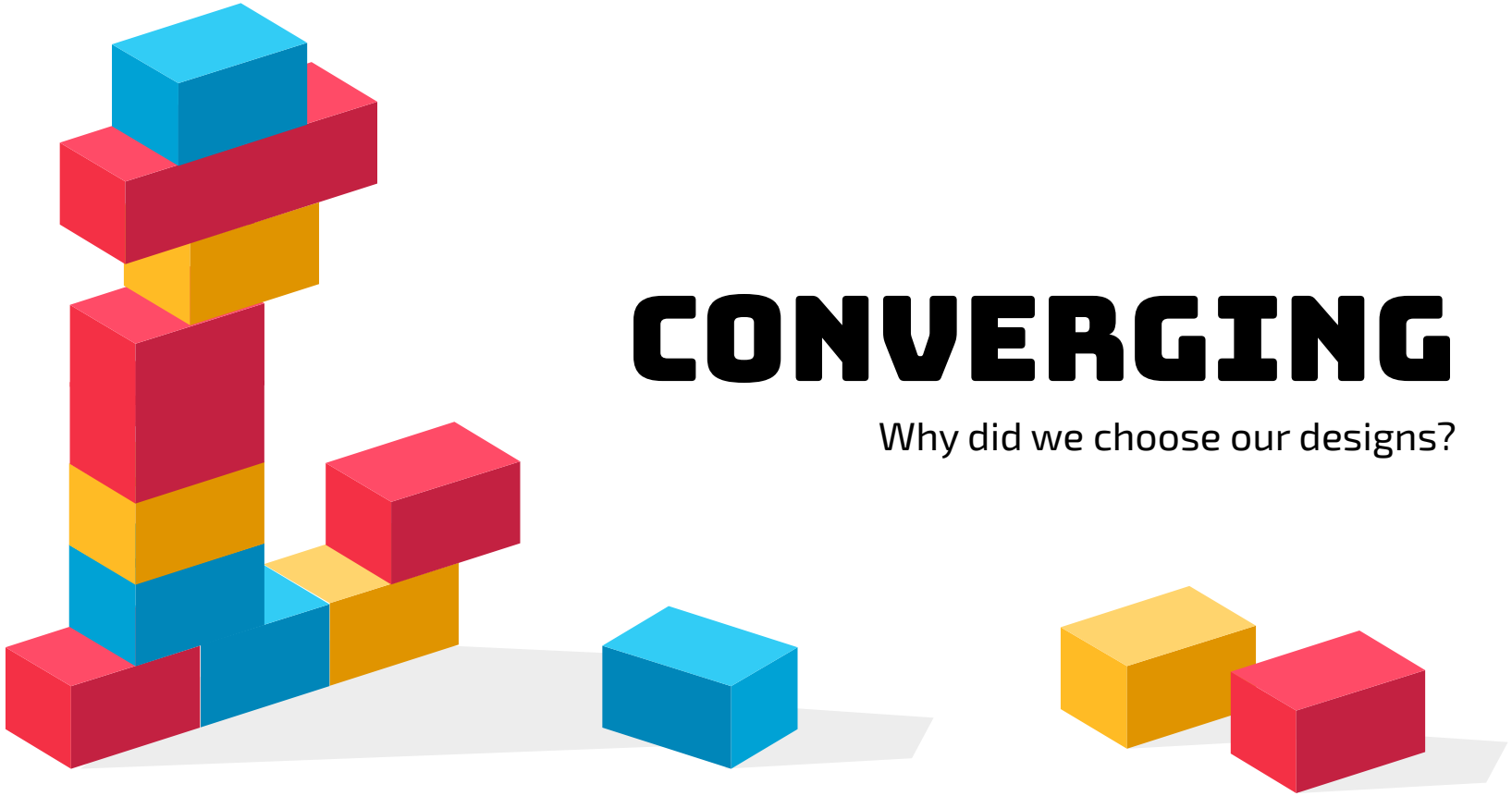


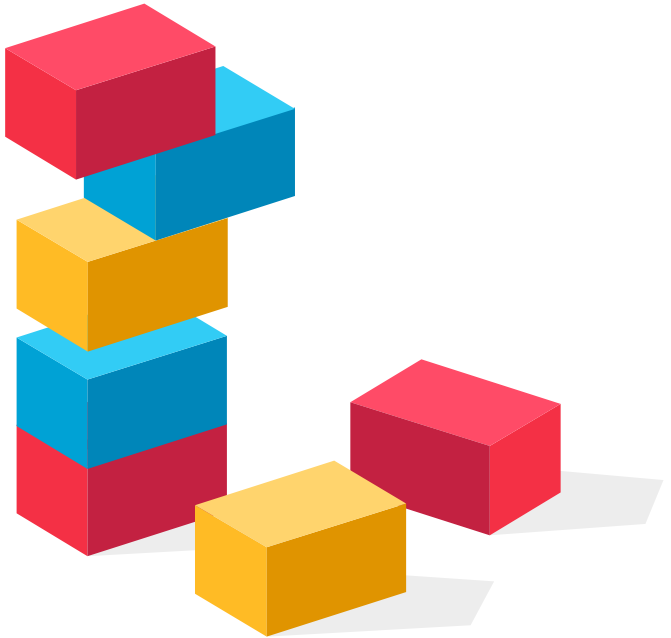
CONVERGING

Why did we choose our designs?

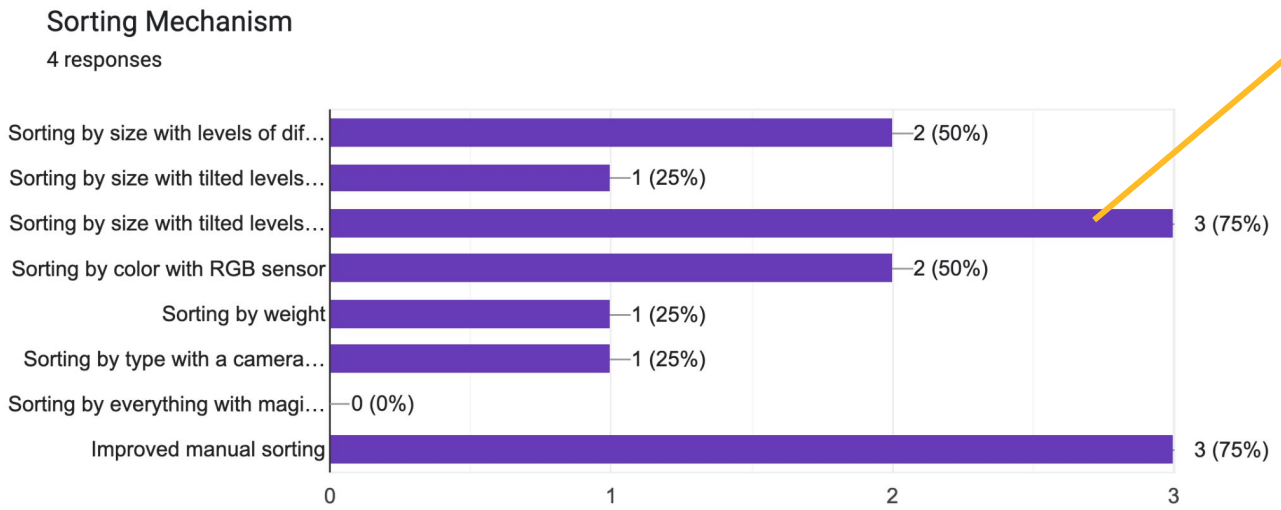
CONV. 1: PAIRWISE "DISCUSSION"

We had around **4-8** different designs per function after diverging, so we used a **multi-vote Google Form** to first vote, then **discuss our voting** verbally.

- Allows us to quickly go through all designs
- Still enables comparison through voting

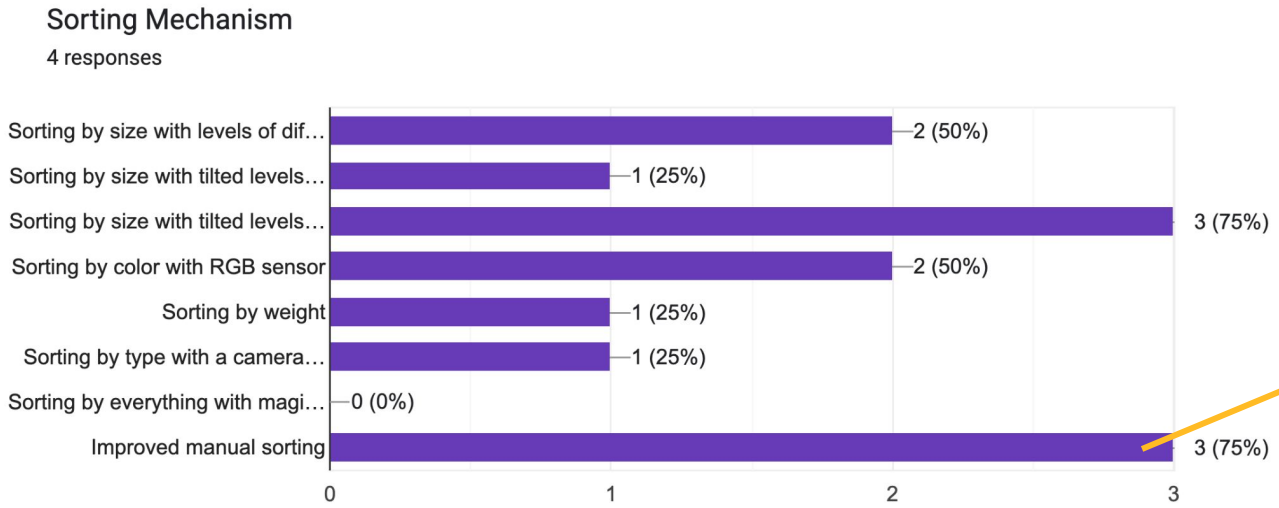


SORTING MECHANISM



Post-discussion consensus: will allow **for more accuracy/feasibility** because of widespread use in industry, compared to the others.

SORTING MECHANISM

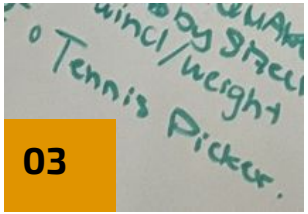


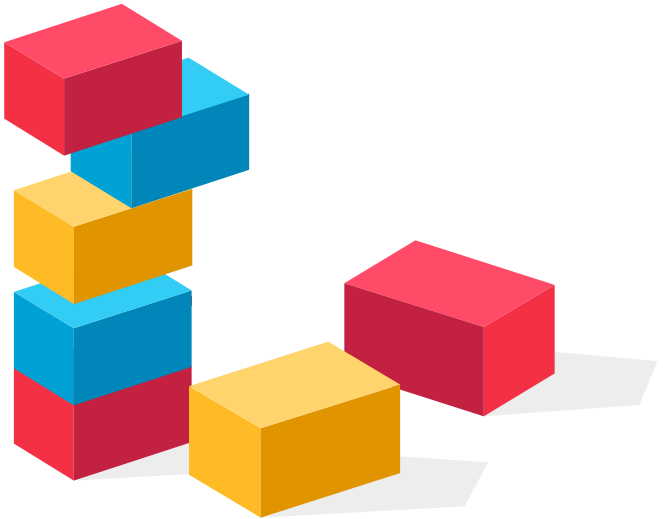
Post-discussion consensus: many TOROLUG members expressed interest in a **design that can also *aid them*** in their sorting, not necessarily a fully automated system.

CONV. 2: POST-LOTUS DISCUSSION

After the Lotus Blossom diverging, we came up with 1 new idea, and revisited an older one: **meat grinder**, and **tennis ball**. We did not converge on these before, but decided to continue with them because they are:

- *Existing reference designs*, increasing feasibility
- *Simple ideas* that are in our everyday lives, that can be easier to replicate





ADDITIONAL CONTENT

COLLECTION "PAIRWISE"

Mechanism for inputting bricks

BRICK OUTPUT "PAIRWISE"

Mechanism for releasing bricks

REQ PAIRWISE

How'd we formally converge on our important requirements?

EFFORT RANKING

How much effort do they want to pitch in?

TIME COMMENTS

How much time do they want to pitch in?

CLUMPING COMMENTS

Are inputting clumped pieces a concern?

SORTING PREFERENCES

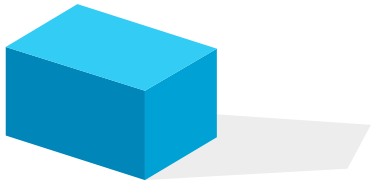
Where does the general emphasis lie in sorting categories?

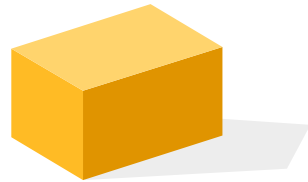
FINAL DESIGN PAIRWISE

How did we converge on a go-foward design?

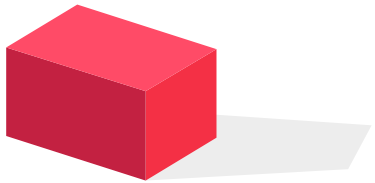
EXTRA DECISIONS

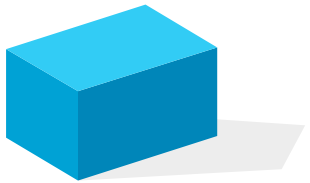
Some extra information on decisions.

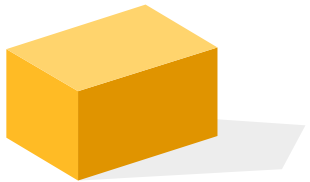




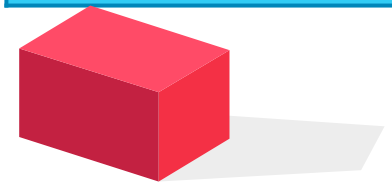
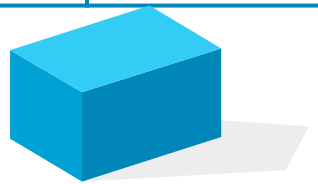
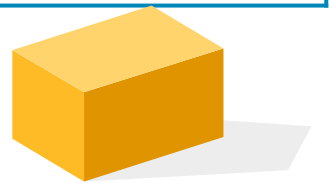
METHOD	TYPE	DESCRIPTION
LEVEL SORTING	Physical	Cardboard stacks w/ different radii
MEAT GRINDER	Drawing	Different rollers with different spacings
WIND	Drawing/calculation	Sorting by weight
TENNIS BALL COLLECTOR	Physical	Legos of the same size as the opening can enter



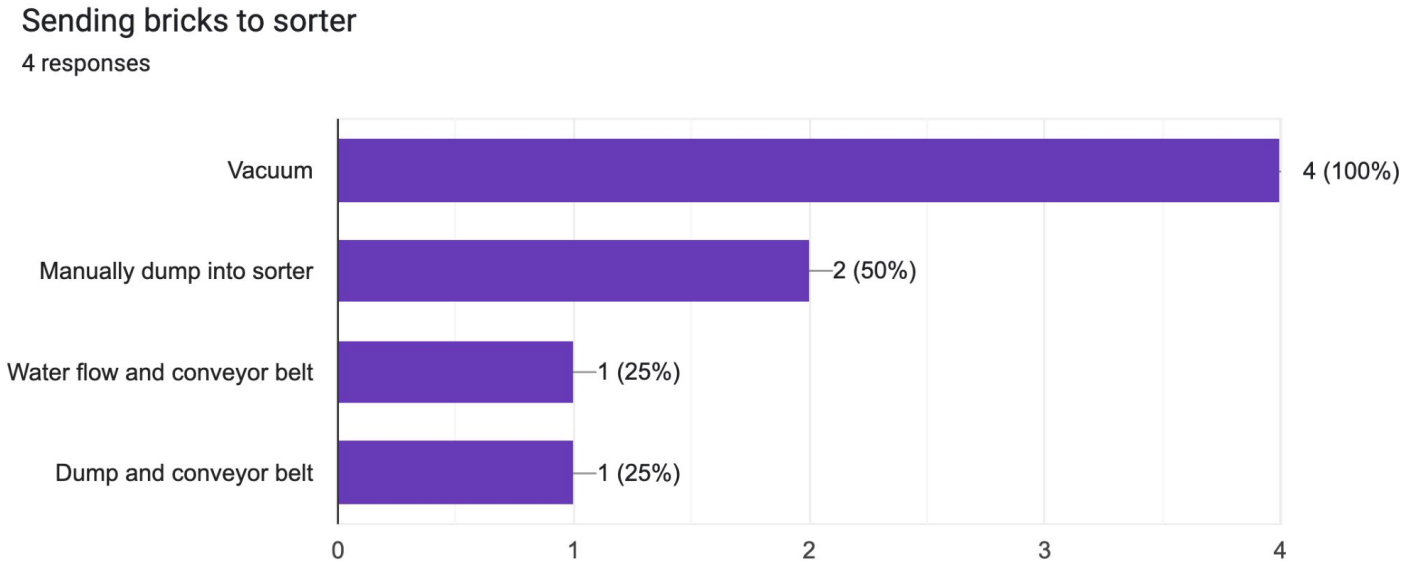




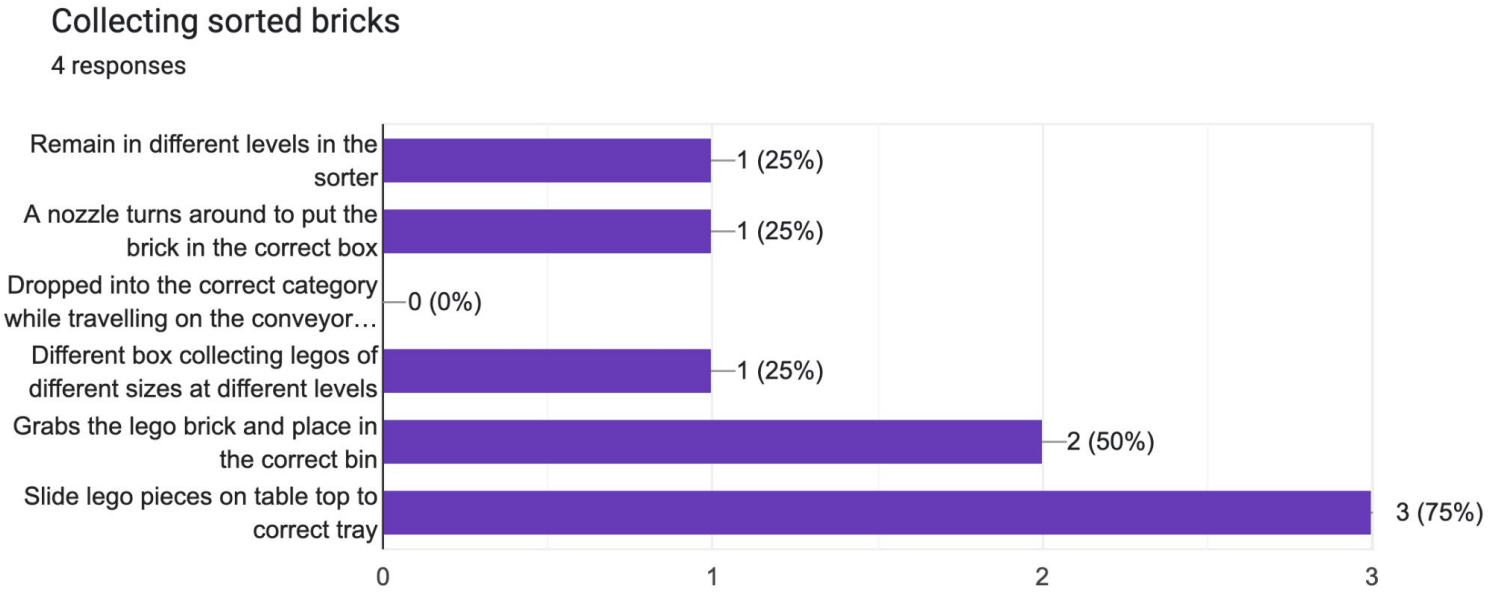
METHOD	TYPE	DESCRIPTION
SORTING STATION	Physical	Box lids with holes cut out for bricks to slide into
COMPUTER VISION/RGB	Drawing	Training a model on recognition of colour or type
TEMPERATURE	Drawing/Calculation	Senses the colour of the brick and sorts

COLLECTION PAIRWISE



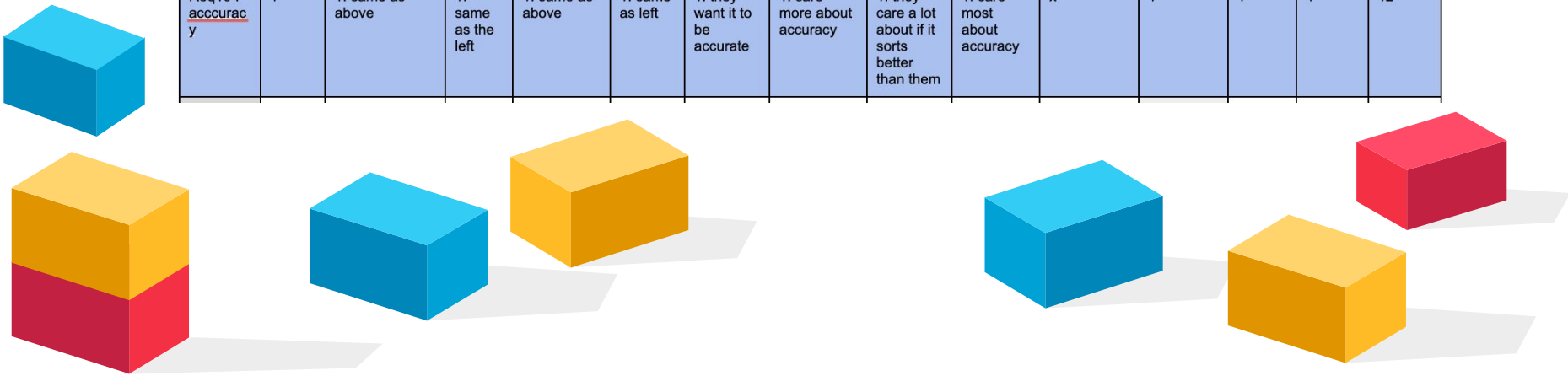
OUTPUT PAIRWISE



REQ PAIRWISE

LINK TO THE PAIRWISE

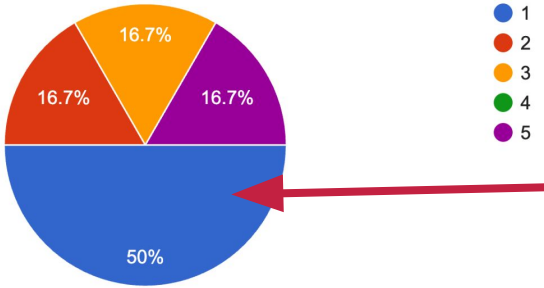
Req8 : cycle time	1	1: same as above	1: same as the left	1: same as above	1: same as left	1: they want it to be quick	1: care more about it being quick	x	1	0	1	1	1	11
Req9 : MTBF	1	1: same as above	1: same as the left	1: same as above	1: same as left	0: they want it to sort	0: care more about how deeply it can sort	0: they care a lot about speed	x	0	0	0	0	5
Req10 : acccuracy	1	1: same as above	1: same as the left	1: same as above	1: same as left	1: they want it to be accurate	1: care more about accuracy	1: they care a lot about if it sorts better than them	1: care most about accuracy	x	1	1	1	12



EFFORT RANKING + COMMENTS

If the LEGO sorting device needed some user labour to work, how much effort (force/labour) would you want to expend on a scale of 1-5 ?

6 responses



Implies that, in general, they want to exert has *little effort as possible*.

Fast and little effort

I don't mind effort (less would be ideal but even 5/5 effort is fine). But anything more than a second or two per piece is more than I'd need to sort it manually.

If the device isn't fast or if it requires a lot of user labour to work then I'd just do the sort manually and skip the machine.

TIME COMMITMENT COMMENTS

If the LEGO sorting device needed some user labour to work, how many minutes or seconds per cycle are you willing to contribute? For reference, in our design, we made a requirement for cycle time to be at most 4 seconds.

(Cycle is defined by the time required to sort one piece)

6 responses

Unlimited

0.5 seconds

5 seconds

1 second

2

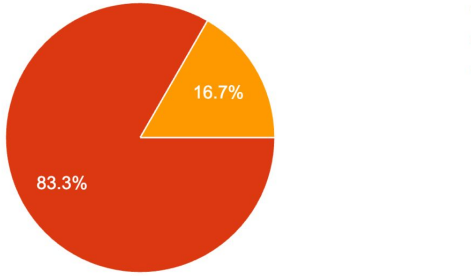
ideally zero. unless it's time to add more pieces to the intake bin where parts are queued for sorting

General consensus: 1-2 seconds maximum

CLUMPING COMMENTS

When you take apart MOCs and sort into bins manually, do you usually have clumps of LEGO bricks, or individual bricks?

6 responses



- Clumps
- Individual bricks
- Individual bricks. I never stack pieces.

Would you be okay with a sorting device that only accepted fully un-clumped bricks?

An elaborated answer is preferred and any comments on the question itself can be written here.

6 responses

Yes

Yes. When I store my Lego bricks, none of them are attached to each other - they are fully 'loose'. So I'm fine providing fully un-clumped bricks to the sorting machine in the first place.

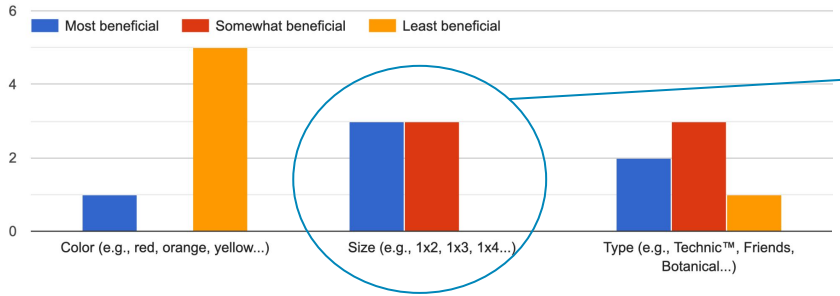
I enjoy breaking down to individual pieces so not an issue

I'd actually prefer a device that doesn't do clumped bricks since most people's storage system is for individual bricks. The device would need to be flexible as to the level of sort it provides in order to match my storage system. For example, I store all my 1x1 bricks together, my 1x2 bricks together so the device would need to sort to that level. Some people store their 1x1 bricks by colour, 1x2 bricks by colour, etc... so the device would need to be flexible to meet those needs. If the device isn't flexible to match my storage system then it wouldn't be of much use as I'd have to do further work to get things put away properly.

General consensus: Okay with unclumped LEGO input

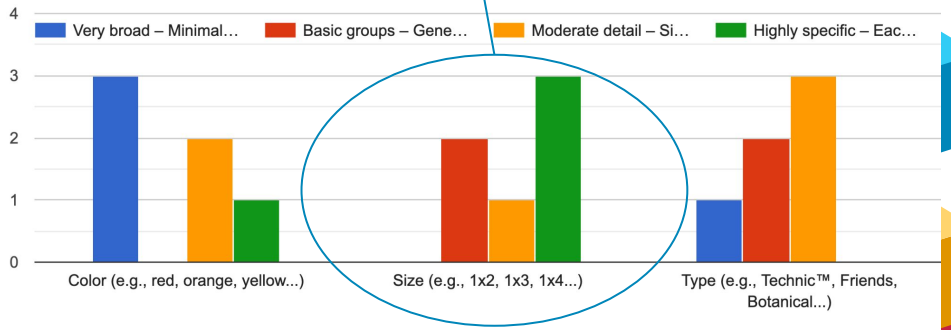
SORTING PREFERENCE

What would you say is the most beneficial genre of sorting?



More emphasis on SIZE, in both sorting detail and genre.

What is the minimum level of sorting detail you find acceptable? (e.g., should red and orange be grouped together or separated when sorting by color?)



FINAL DESIGN PAIRWISE

	Meat Grinder	Tennis Ball	Level Sorter	Wind	Total
Meat Grinder	x	1: More simple to operate, and less hands-on effort for rolling up to collect the LEGO	0	1: Requires less electricity to operate, if any. ToroLUG members mentioned in Zoom call that they may not have power outlets to be able to operate devices.	1
Tennis Ball	0	x	0	0	0
Level Sorter	1: More structured way of sorting by size, and less of a continuum. Categories are selected by diameters of holes, rather than width.	1: More simple to operate, and less hands-off than rolling up and collecting all the LEGO to sort.	x	1: May be disparities in densities of pieces, pieces may overlap, etc. which can be prevented by using gravity instead of pressurized air jets. Gravity naturally brings the pieces down, while the jets push sideways, which may be prone to error due to friction or other pieces being weighed down.	3
Wind	0	1: More simple to operate, and less hands-off than rolling up and collecting all the LEGO to sort.	0	x	1

	Computer Vision	Laser RGB Sensor	Aided Sorting	Total
Computer Vision	x	0	0	0
Laser RGB Sensor	1: Would be less bulky of a setup and take up less size if it detected colour through this rather than a fully-functioning camera, which may require a lot more power as well	x	0	1
Aided Sorting	1: This method works with the skills that ToroLUG members *already have* with sorting, except it helps them speed it up. ToroLUG members may be more comfortable sorting pieces by hand into categories that they are free to change to their needs.	1: This method works with the skills that ToroLUG members *already have* with sorting, except it helps them speed it up. ToroLUG members may be more comfortable sorting pieces by hand into categories that they are free to change to their needs.	x	2

RADII DECISIONS

I settled on the largest hole being 1.125 inches which is slightly smaller than a 4-stud diameter part (approximately 1.25 inches). I really didn't see a need to have an additional size above that. Parts that size and above are really quick to sort through. For the smallest size I chose 0.5 inches which is slightly smaller than a 2-stud diameter part (approximately 0.625 inches). Having these two sizes was good enough for me to get started and check the results. The hole sizes were also limited to the tools I had on hand.