Dice table

EXHIBIT DESIGN

A physical model of exponential distribution using dice

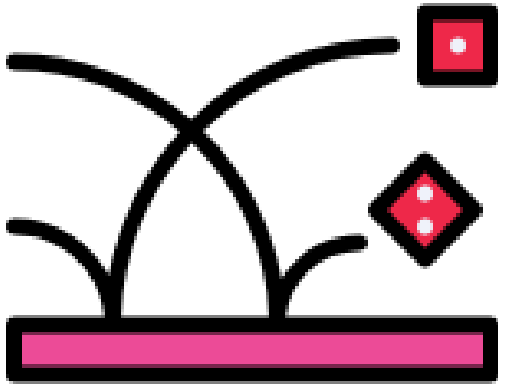
Team Members
Subhash Chandra (CCE, IISc)
Nidhi Joshi (CPDM, IISc)

Mentor
Prof. Amit Apte (ICTS-TIFR)

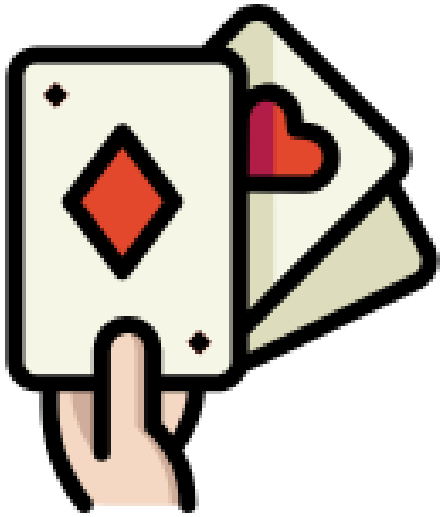
Understanding the mathematics

What is probability?

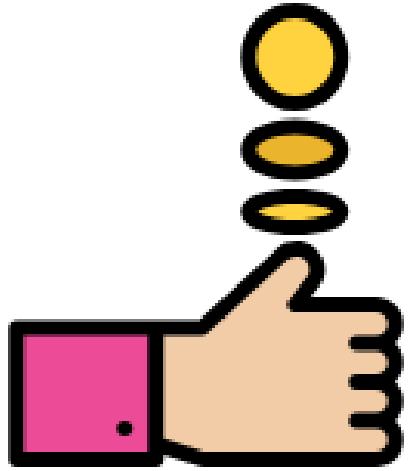
DICE



CARDS



COINS



Exponential Distribution - The Math

- Formula for probability density function of the exponential distribution is –

$$f(x)=1/\beta\, e^{-(x-\mu)/\beta} \qquad \text{where } x \geq \mu,\ \beta > 0$$

μ is locator parameter; β is scale parameter

- Where, μ=0 and β= 1 - **Standard exponential distribution**
- Formula for standard exponential distribution is –

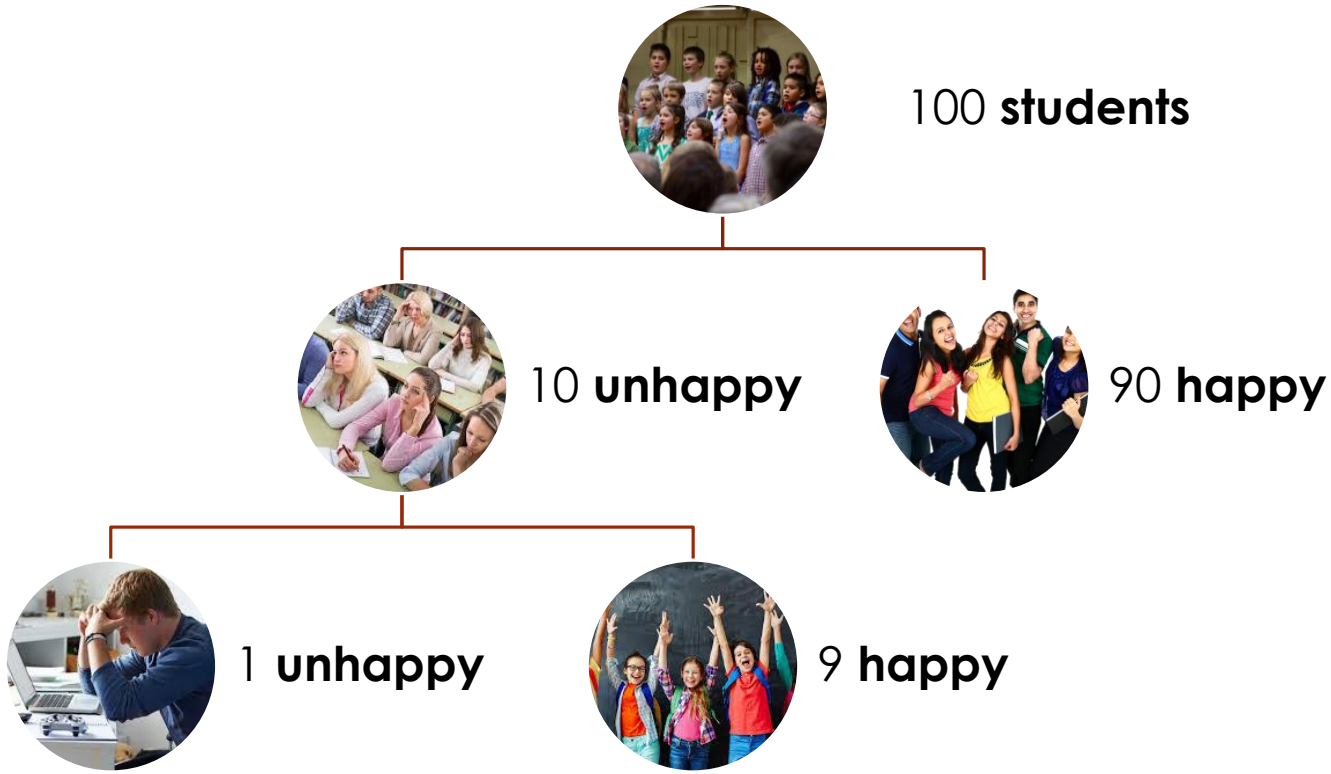
$$f(x)=e^{-x} \qquad \text{for } x \geq 0$$

Exponential Distribution - An example

- 100 students in a class
- Professor gives a project to everyone
- 90% - Happy with project allotted
- 10% - Unhappy with project allotted
- Unhappy student visit professor to change the project again

In how many rounds does the professor can make everyone happy?

Exponential Distribution - Tree Representation

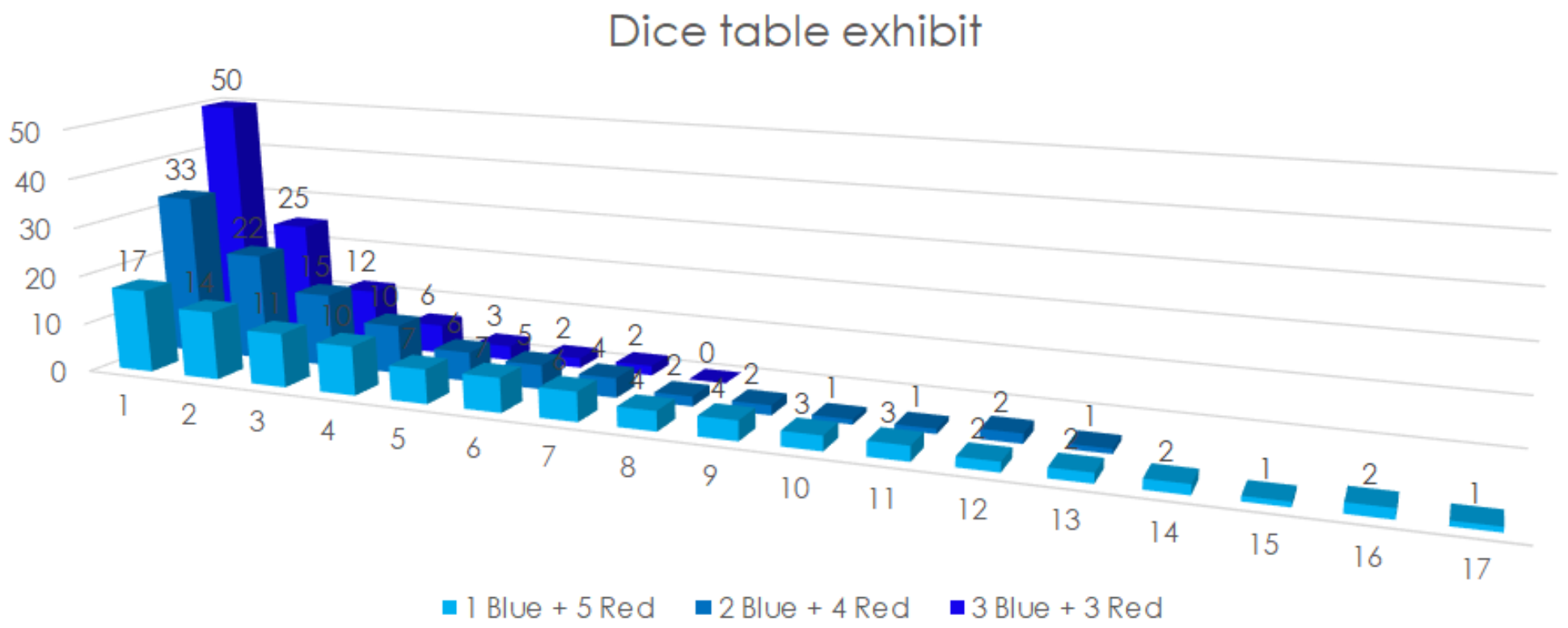


Exponential Distribution - The dice table

- 3 types of dice
  - 1 Blue + 5 Red
  - 2 Blue + 4 Red
  - 3 Blue + 3 Red
- N = total no. of dice of each type

- 1^{st} throw, P (blue dice) = N x (⅙)
- 2^{nd} throw, P (blue dice) = N x (⅙) x (⅚)
- 3^{rd} throw, P (blue dice) = N x (⅙) x (⅚) x (⅚)
- .
- .
- .
- k^{th} throw, P (blue dice) = N x (⅙) x $(⅚)^{k-1}$

Exponential Distribution - The dice table



Designing the exhibit

Current exhibit - MPE 2013

ISSUES

- Time consuming
- Effort intensive
- Heavy & Bulky
- Needs 3 setups
- No depiction of convergence
- Poor aesthetics

Exhibit Requirements

Issue Category	Understood Requirements	Understood Sub Requirements	Req #	D / W
Participant Engagement	Exhibit must be engaging	Exhibit must have aesthetic value	R1	Wish
		Should depict the mathematical concept with clarity	R2	Demand
		Should allow interaction of the participant with the exhibit	R3	Demand
Participation Effort	Reduce effort required to conduct experiment	Reduce number of people required to conduct experiment	R4	Demand
		Reduce number of steps to conduct experiment	R5	Demand
		Reduce effort of each step of experiment	R6	Demand
Participation time	Reduce time required to conduct experiment	Time required for each step	R7	Demand
Accessibility	Exhibit must be accessible to all participants	Height must be comfortable for kids and adults	R8	Demand
		Colour combination to accommodate color blind participants	R9	Demand
		Size of dice should be comfortable to press	R10	Demand
		Access points of exhibit (top view area) should be within reach	R11	Demand

Exhibit Requirements

Issue Category	Understood Requirements	Understood Sub Requirements	Req #	D / W
Ruggedness	Exhibit must be rugged	Must not be damaged during transportation	R12	Demand
		Must not be damaged during storage	R13	Demand
		Must sustain interaction with participants during exhibition	R14	Demand
		Must be able to sustain outdoor conditions	R15	Wish
Assembly	Easy to assemble/ disassemble exhibit	Should not require speciality tool	R16	Demand
		Should be able to assemble/ carried by single person	R17	Demand
		Assembly sequence should be clear to follow	R18	Demand
Stand alone	Must function as an independent exhibit	Must function as an independent exhibit	R19	Wish
Safety	Interaction with exhibit must be safe for participant	Safe to assemble	R20	Demand
		Safe when participant is interacting with it	R21	Demand
Mathematic concept	Design and functioning should not undermine depiction of mathematical concept	Probability of throwing dice should not be affected	R22	Demand
		Side of dice thrown should not change when handling dice	R23	Demand

Requirements ranking

Req #	Understood Sub- requirement	Sum	Rank
R22	Probability of throwing dice should not be affected	15.5	1
R23	Side of dice thrown should not change when handling dice	15.5	2
R14	Must sustain interaction with participants during exhibition	13.5	3
R2	Should depict the mathematical concept with clarity	13	4
R3	Should allow interaction of the participant with the exhibit	13	5
R8	Height must be comfortable for kids and adults	13	6
R11	Access points of exhibit (top view area) should be within reach	12.5	7
R21	Safe when participant is interacting with it	12.5	8
R5	Reduce number of steps to conduct experiment	12	9
R7	Time required for each step	11.5	10

Requirements ranking

Req #	Understood Sub- requirement	Sum	Rank
R9	Colour combination to accommodate color blind participants	11.5	11
R6	Reduce effort of each step of experiment	10.5	12
R10	Size of dice should be comfortable to press	10	13
R4	Reduce number of people required to conduct experiment	6	14
R20	Safe to assemble	5.5	15
R12	Must not be damaged during transportation	4.5	16
R13	Must not be damaged during storage	3.5	17
R16	Should not require speciality tool	2.5	18
R18	Assembly sequence should be clear to follow	2	19
R17	Should be able to assemble/ carried by single person	2	20

Technical Requirements

TR #	Technical requirements	Units	Factors affected
T1	Number of dice of each type	nos.	Number of steps, Time, Effort
T2	Number of types of dice	nos.	Number of steps, Time, Effort
T3	Dimensions of dice	mm x mm x mm	Ergonomics - Handling
T3	Height of exhibit - Dice throwing surface	cm	Ergonomics - Height
T4	Dimensions of exhibit - Dice throwing surface	cm x cm	Ergonomics - Reach
T6	Number of columns - Dice representation	nos.	Aesthetics, Mathematic concept
T7	Cross section of column - Dice representation	mm x mm	Mathematic concept, Probability
T8	Max. height of column	cm	Mathematic concept, Probability
T9	Weight of exhibit	kg	Ergonomics - Transport, Assembly

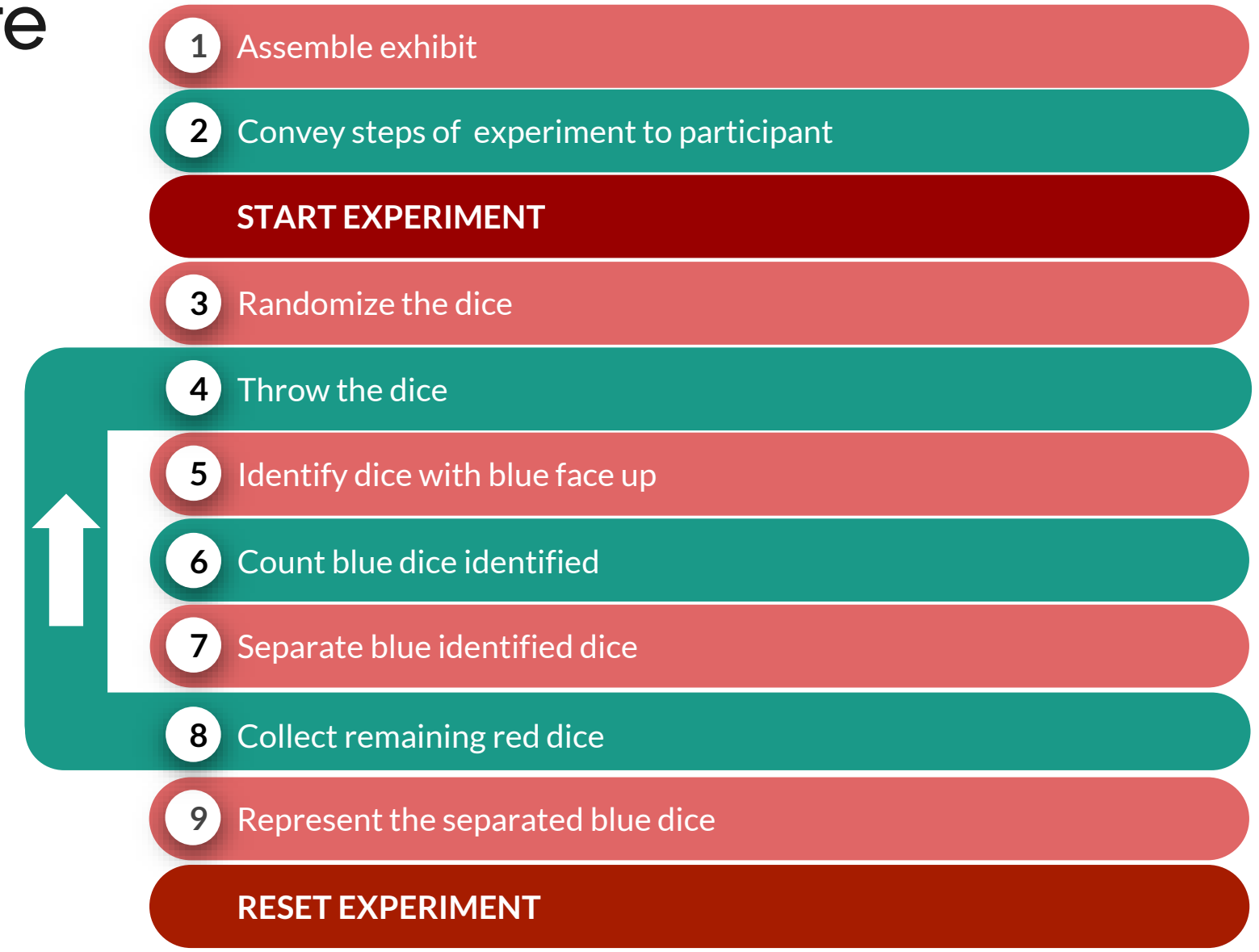
Requirements ranking

Req #	Understood Sub- requirement	Sum	Rank
R9	Colour combination to accommodate color blind participants	11.5	11
R6	Reduce effort of each step of experiment	10.5	12
R10	Size of dice should be comfortable to press	10	13
R4	Reduce number of people required to conduct experiment	6	14
R20	Safe to assemble	5.5	15
R12	Must not be damaged during transportation	4.5	16
R13	Must not be damaged during storage	3.5	17
R16	Should not require speciality tool	2.5	18
R18	Assembly sequence should be clear to follow	2	19
R17	Should be able to assemble/ carried by single person	2	20

SNPS

To design a **rugged** and **safe** exhibit which conveys the mathematical **concept of exponential distribution**, by **interacting** with exhibition participants requiring **minimum time** and **effort**, and high engagement.

Function Structure



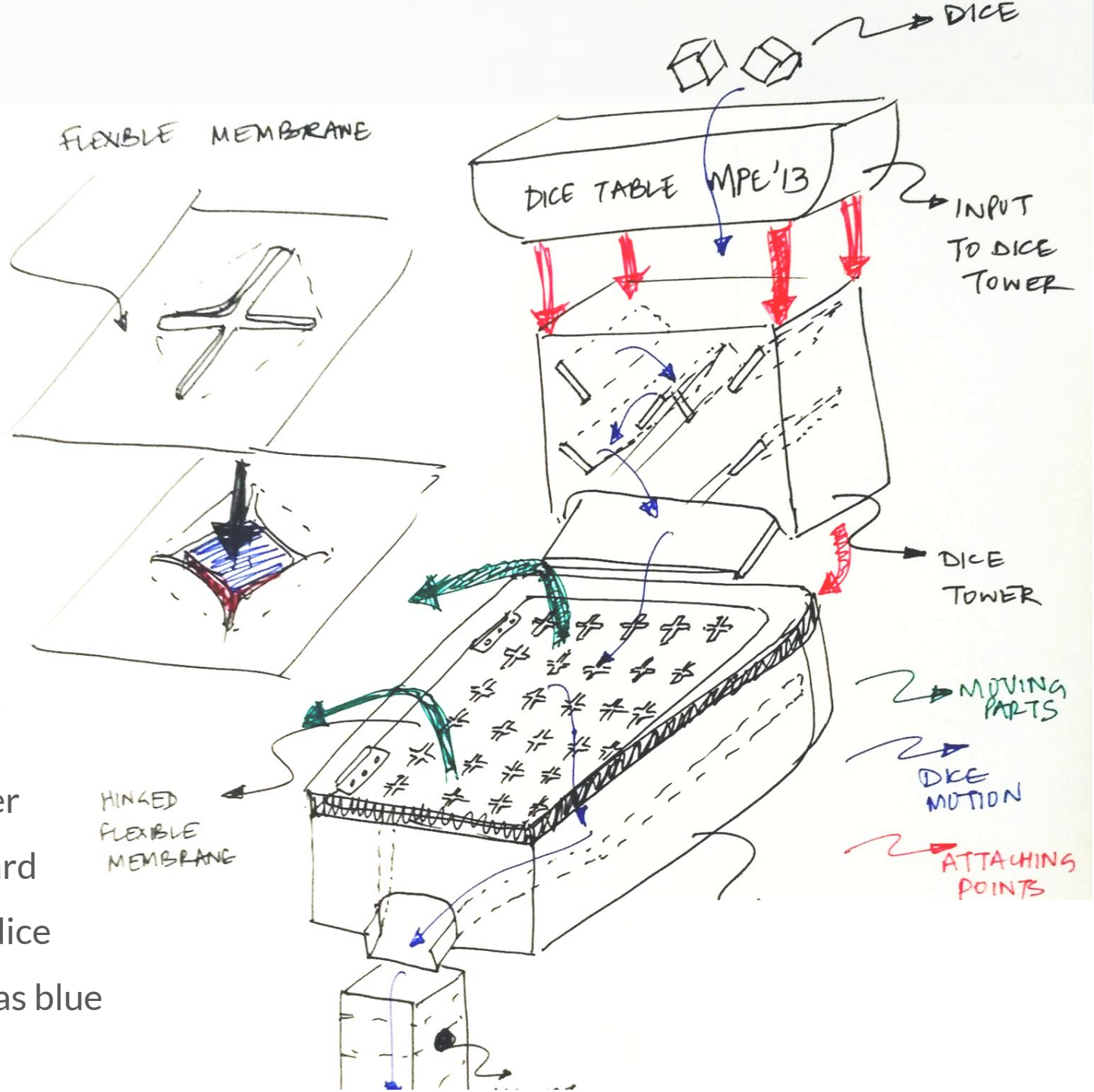
Brainstorming

Assemble exhibit	Fixed architecture		Modular design		Nut Bolt		Snug fit	
Instructions for experiment	Verbally explained by exhibit personnel			Poster explaining the experiment and steps			Audio prompt at each step	
Randomizing the dice	Open bowl to mix and throw		Salt shaker box		Magic ball lottery		Dice tower	
Throwing dice	By hand				Thrown from a contraption			
Identify blue dice	Visually		Image processing			Colour sensor		
Counting blue dice	Manual counting (Point and count)		Colour sensor		By weight of separated dice		By measuring against a graduated vertical scale	
Separate blue dice	Hand pick	Magnetic lift	Velcro lift	Elastic band matrix	Cross Pattern on plastic flex sheet		Robotic arm	Conveyor belt + Color sensor ID
Representing blue dice	Stacking of dice	Digital display	LED light up board	Marker on acrylic sheet	Wire/ ribbon which adjusts to level of stacks		Measuring tape against the stack	
Resetting experiment	Spring loaded trap door at bottom of rep board		Collect into box and load into mixing mechanism		Have extra pieces of dice available to do next experiment while this is emptied		Have a conveyor pick up belt which carries it up to the dice to mixing mechanism	
Convergence representation	LED screen showing convergence by digitally sensing for each throw		Sensor which measures the height of the stack		Data entry interface for each experiment result		Update each data entry to social media/ cloud and have it show you the current convergence result.	

Final Concept

STEPS

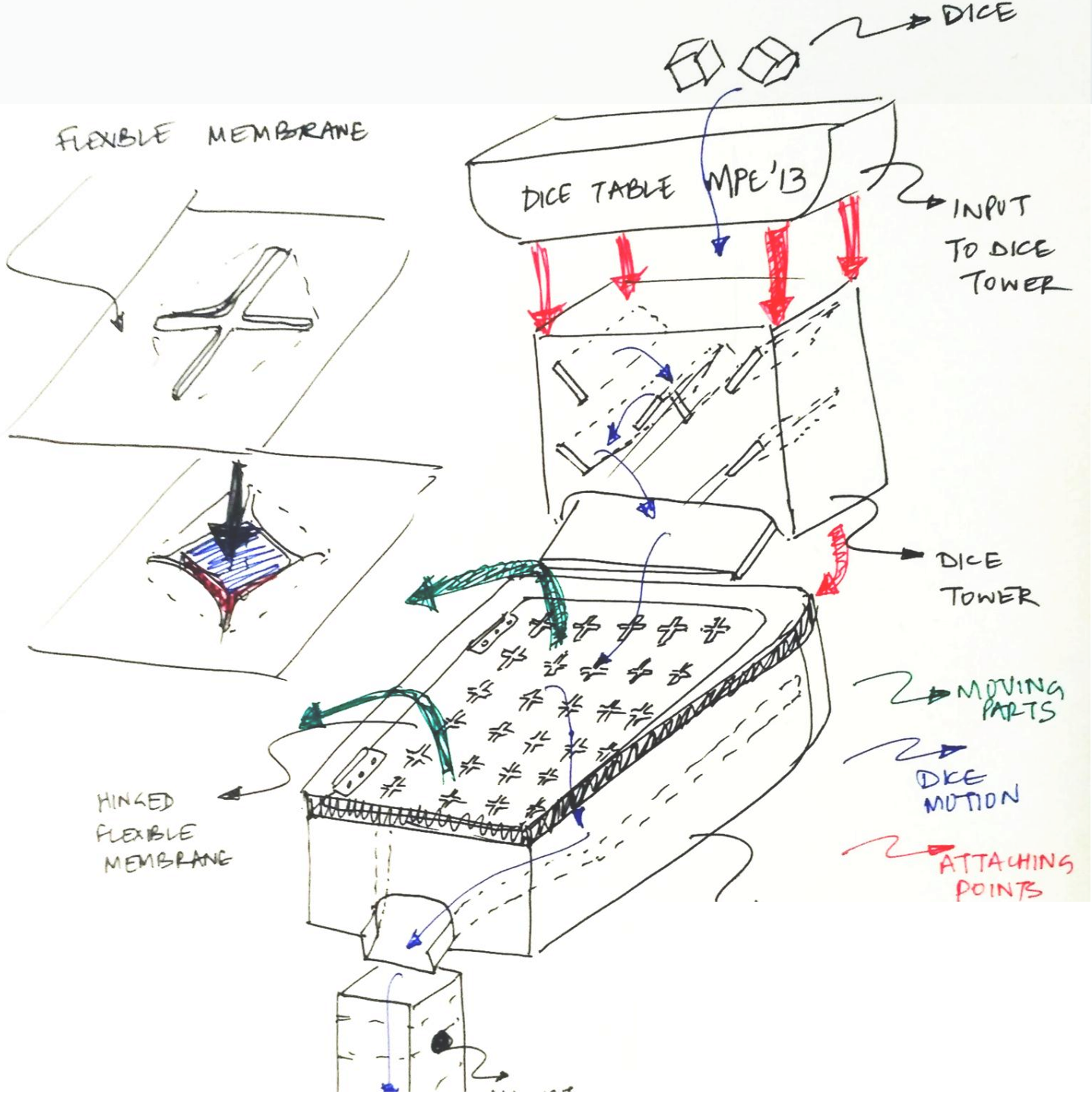
- Put dice into Dice tower input
- Randomization through dice tower
- Exits from bottom of dice tower
- Visually locate blue dice
- Push through silicone membrane
- Collect blue dice into graduated beaker
- Stick beakers onto representation board
- Flip silicone membrane to collect red dice
- Repeat experiment till all dice appear as blue



Final Concept

FEATURES

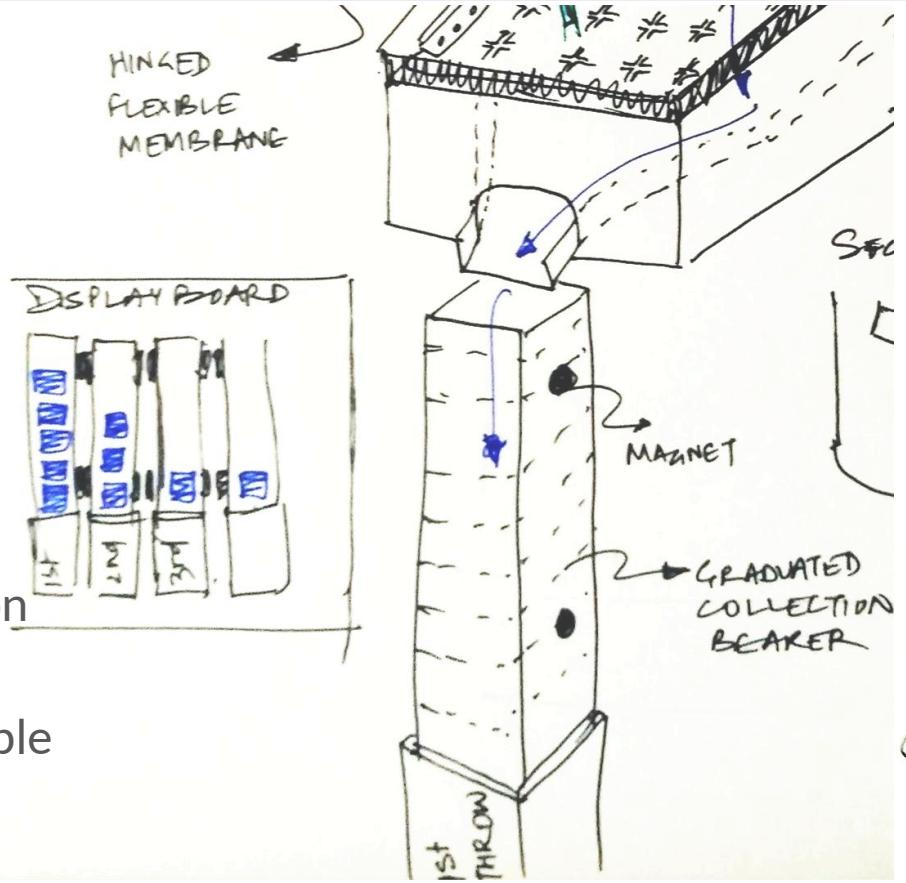
- Dice tower
  - See through
  - Randomized dice faces
- Dice separation
  - Easy to push
  - Fun activity
- Modular sub systems
  - Easy to store
  - Less space taken during transport

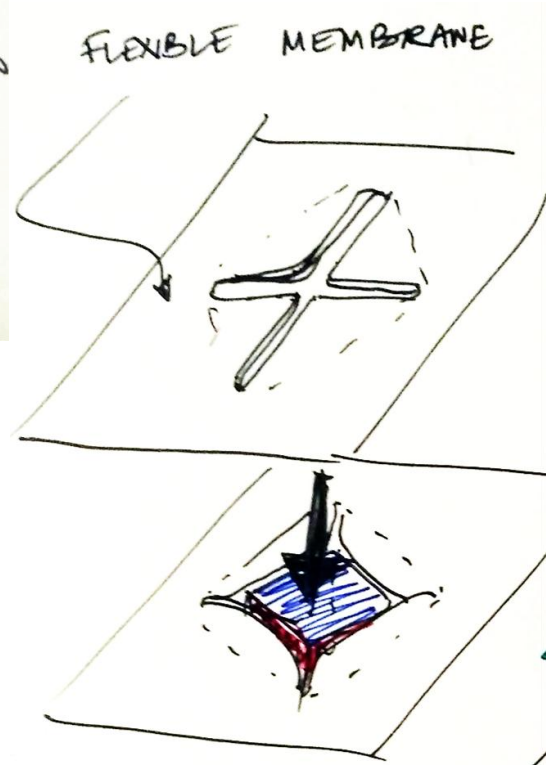


Final Concept

FEATURES

- Dice representation
  - Collection in graduated cylinders
  - Magnetic stick onto representation board
  - Can add as many beakers as possible
- Modular sub systems
  - Easy to store
  - Less space taken during transport
- Safety
  - Silicone layer
  - No sharp edges during pushing





Work ahead

- Isolate problem with current MPE 2013 exhibit
- Generate concept designs
- Finish proof of concept - Trials of dimensional variations on laser cutter
- Freeze final design dimensions - based on trials
- Procure materials
- Fabrication
- Assembly of fabricated parts

Target date: 15th July 2018