

Proc. 29th Annual Conference of the International Group for Lean Construction (IGLC29), Alarcon, L.F. and González, V.A. (eds.), Lima, Peru, doi.org/10.24928/2021/0117

# TEACHING TARGET VALUE DESIGN FOR DIGITAL FABRICATION IN AN ONLINE GAME: OVERVIEW AND CASE STUDY

Ming Shan NG and Daniel Mark HALL

Chair of Innovative and Industrial Construction, ETH Zurich

# **MOTIVATION**

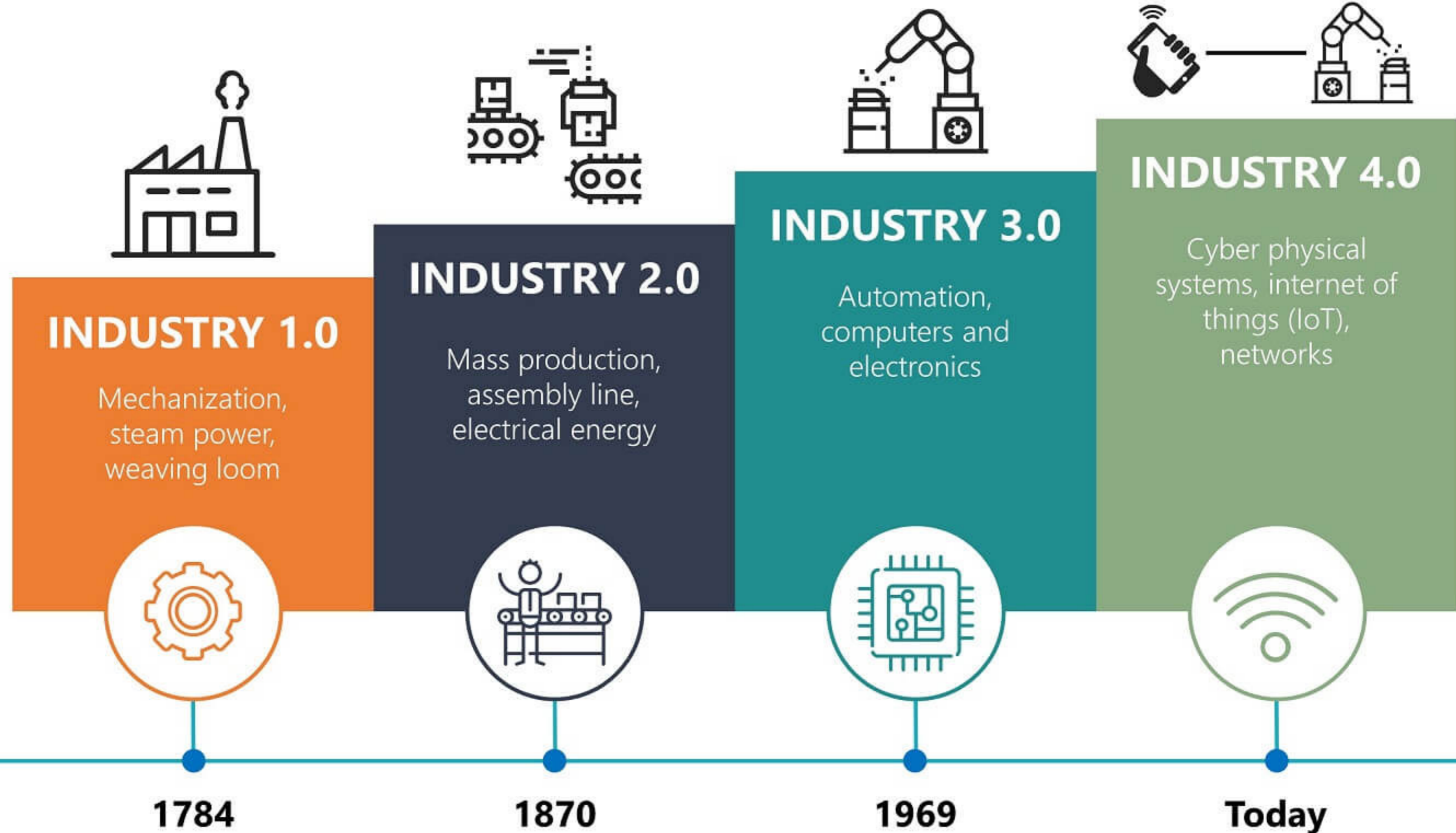
# **STATE-OF-THE-ART**

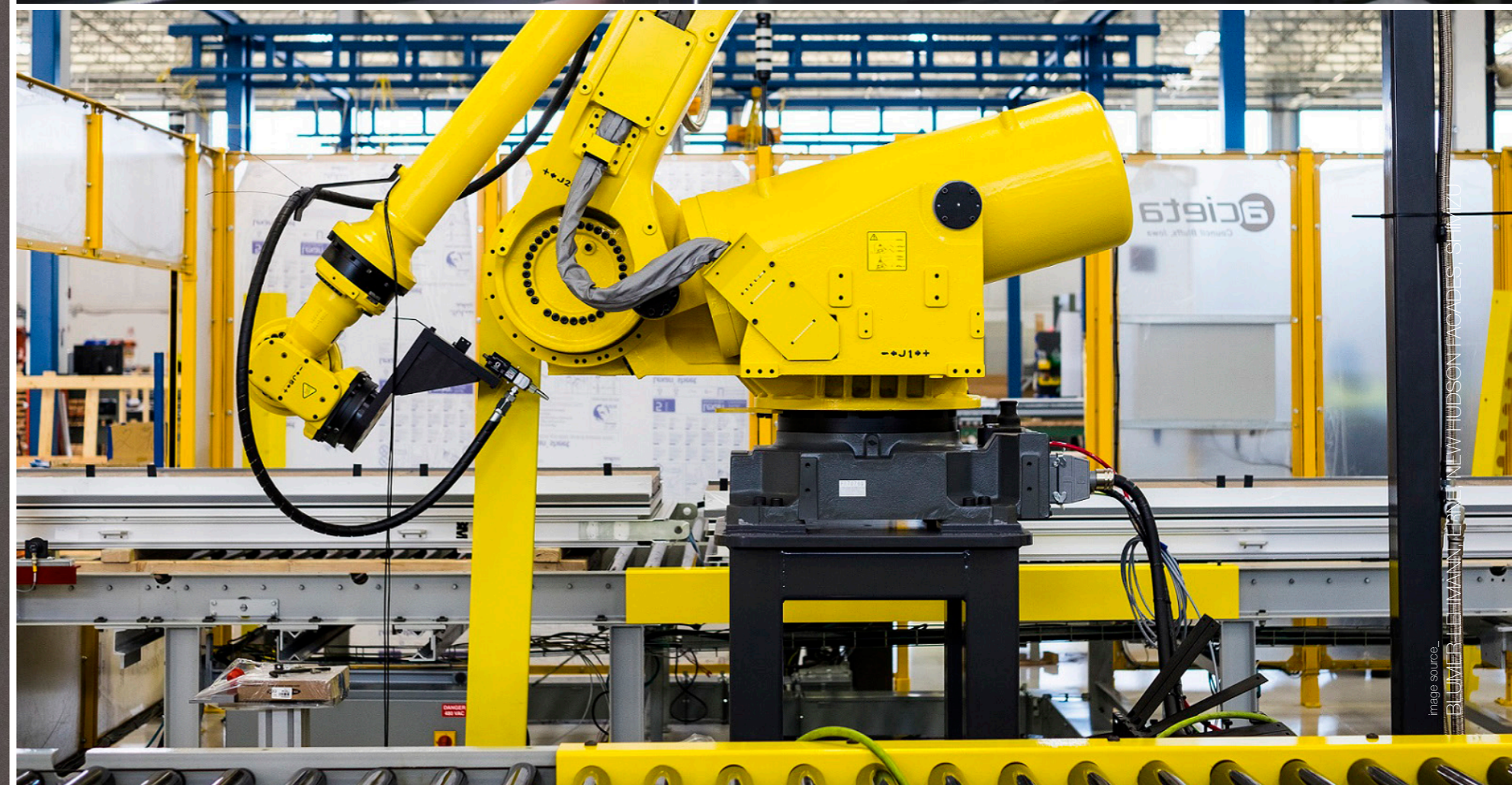
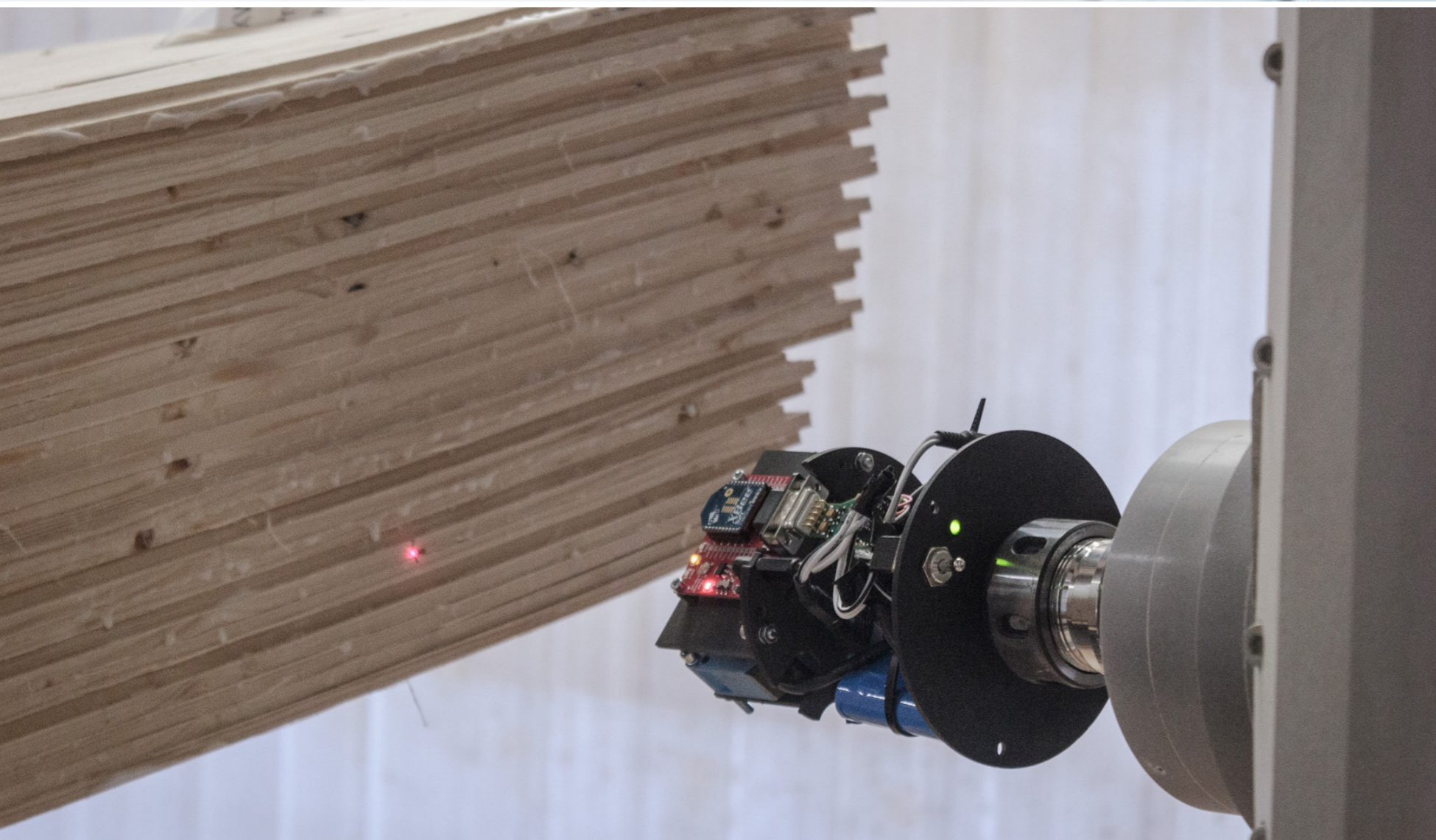
# **RESEARCH GAP**

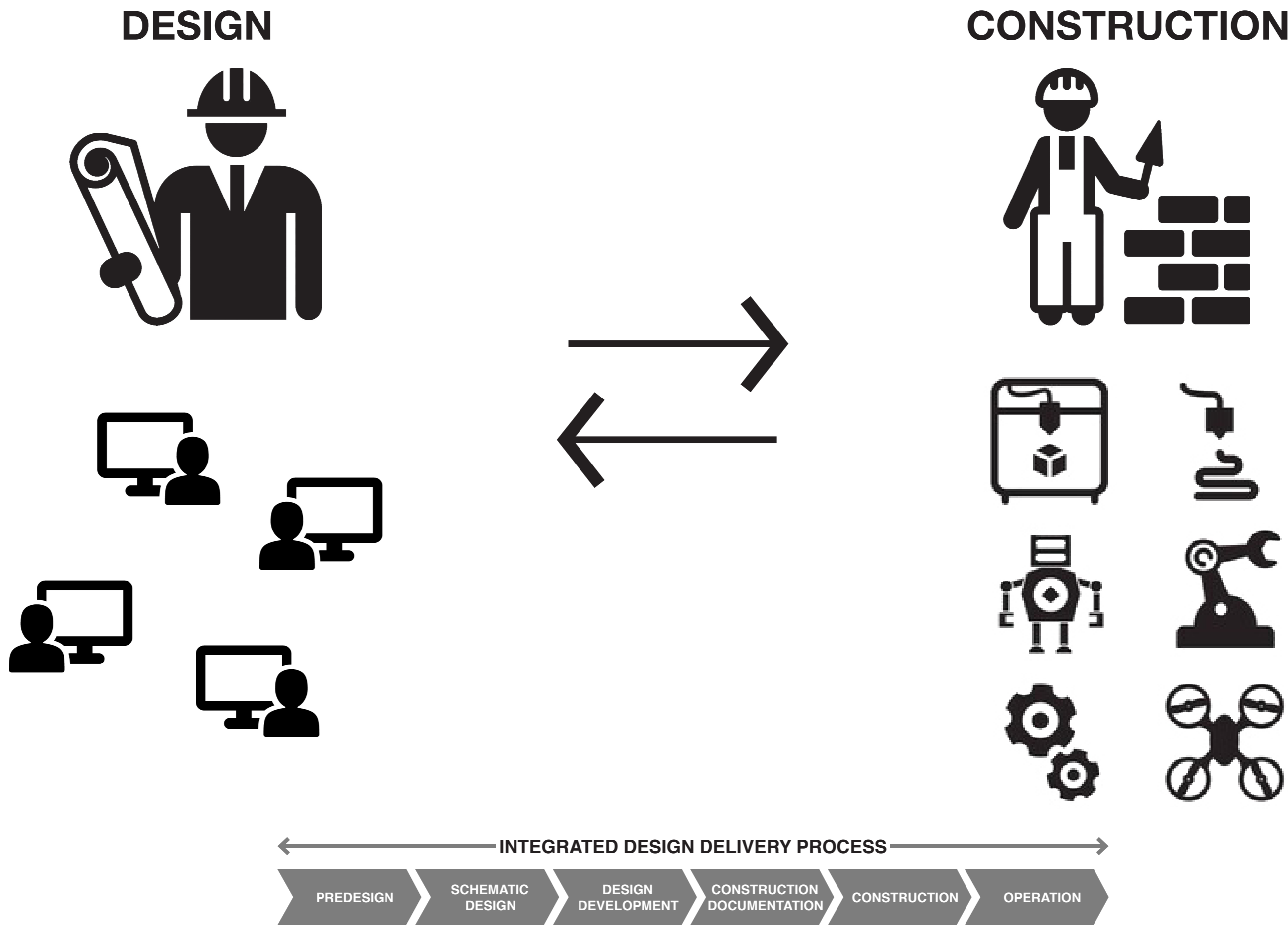
# **GAME DESCRIPTION**

# **CASE STUDY RESULTS**

# **DISCUSSION**





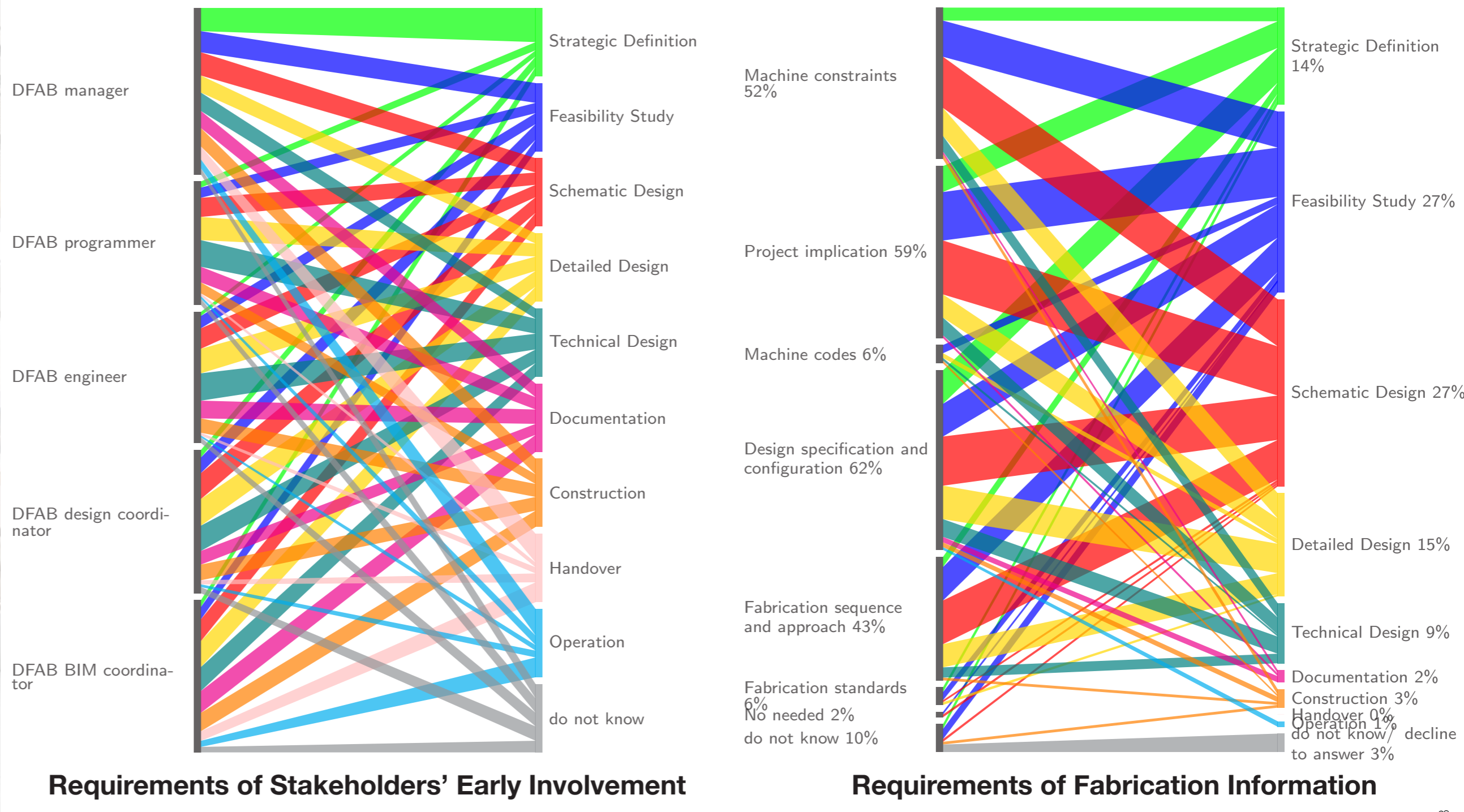


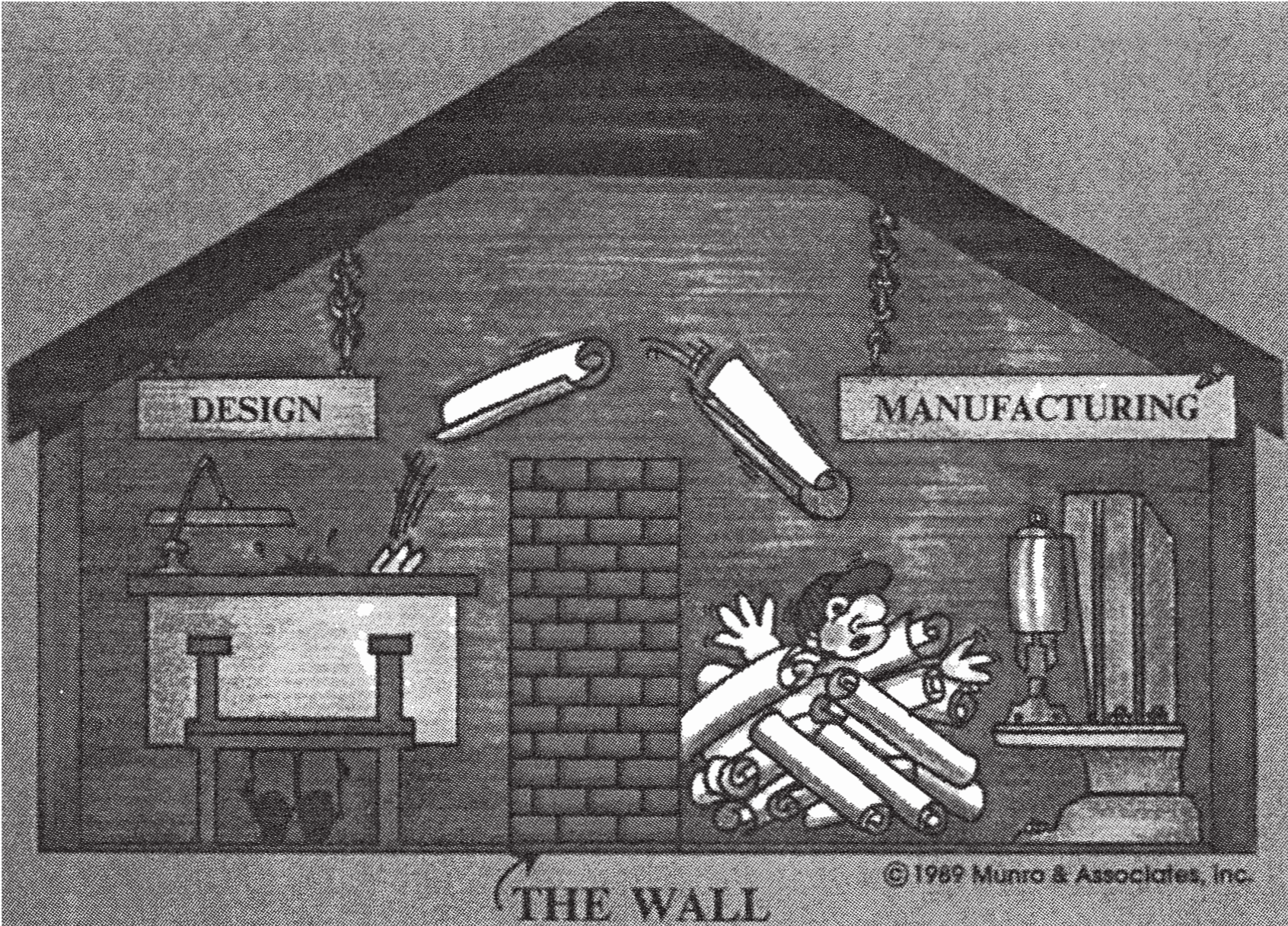
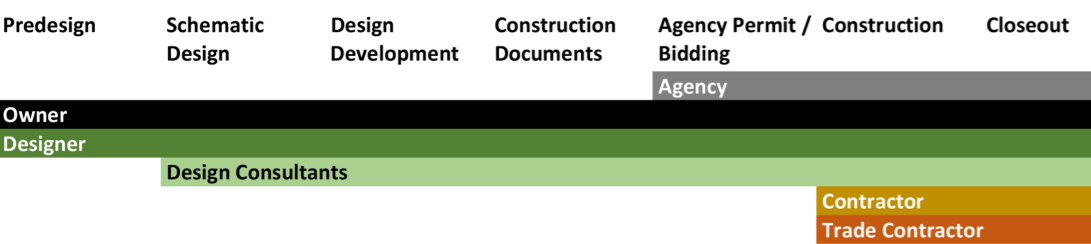
Ng, M. S., Bonanomi, M. M., Hall, D. M., & Hackl, J. (2020). "Design for Digital Fabrication: an Industry needs Analysis of Collaboration Platforms and Integrated Management Processes." Proc. of the 37th ISARC, 318–325. Kitakyshu, Japan

Ng, M. S., & Hall, D. M. (2019). "Toward Lean Management for Digital Fabrication: a Review of the Shared Practices of Lean, DiMA and DFAB." Proc. 27th Ann. Conf. IGLC 2019, 725–736.

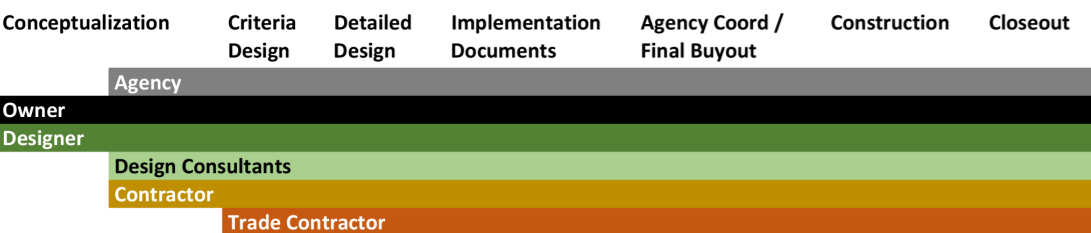


# DIGITAL FABRICATION REQUIRES INTEGRATED INFORMATION AND ORGANISATION



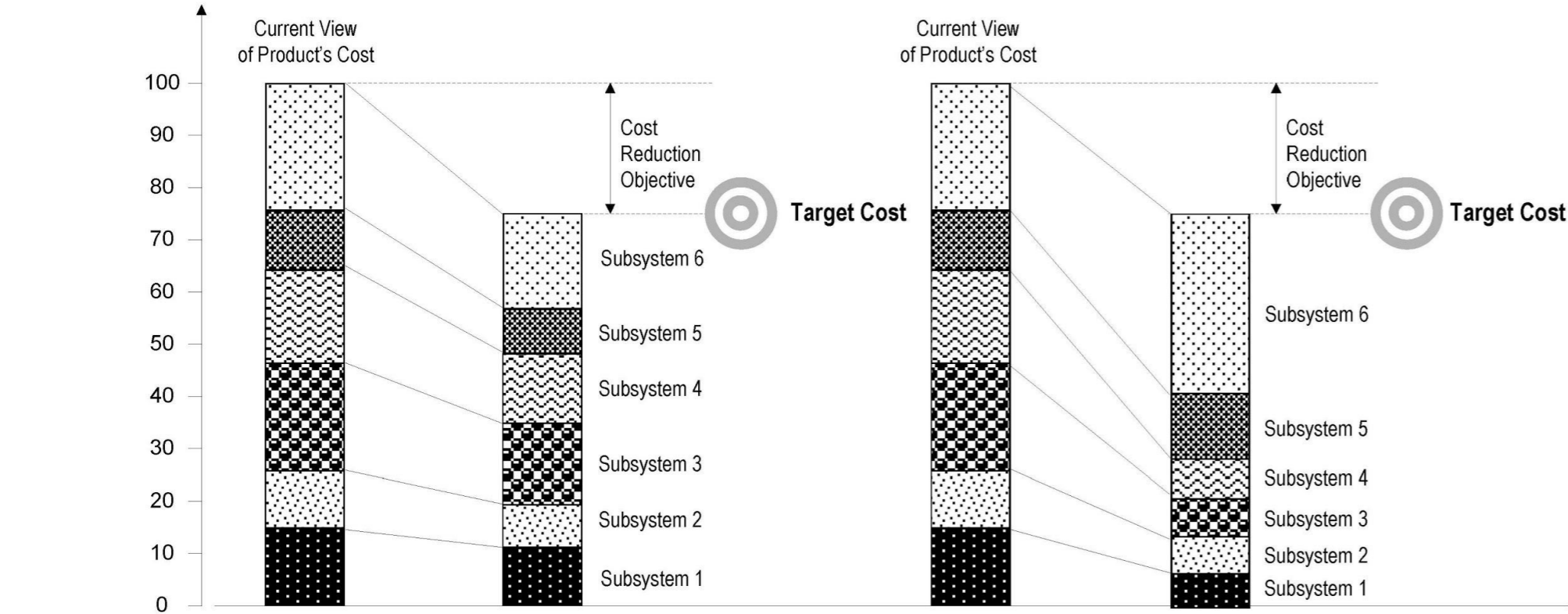


DISCRETE  
DESIGN-BID-BUILD

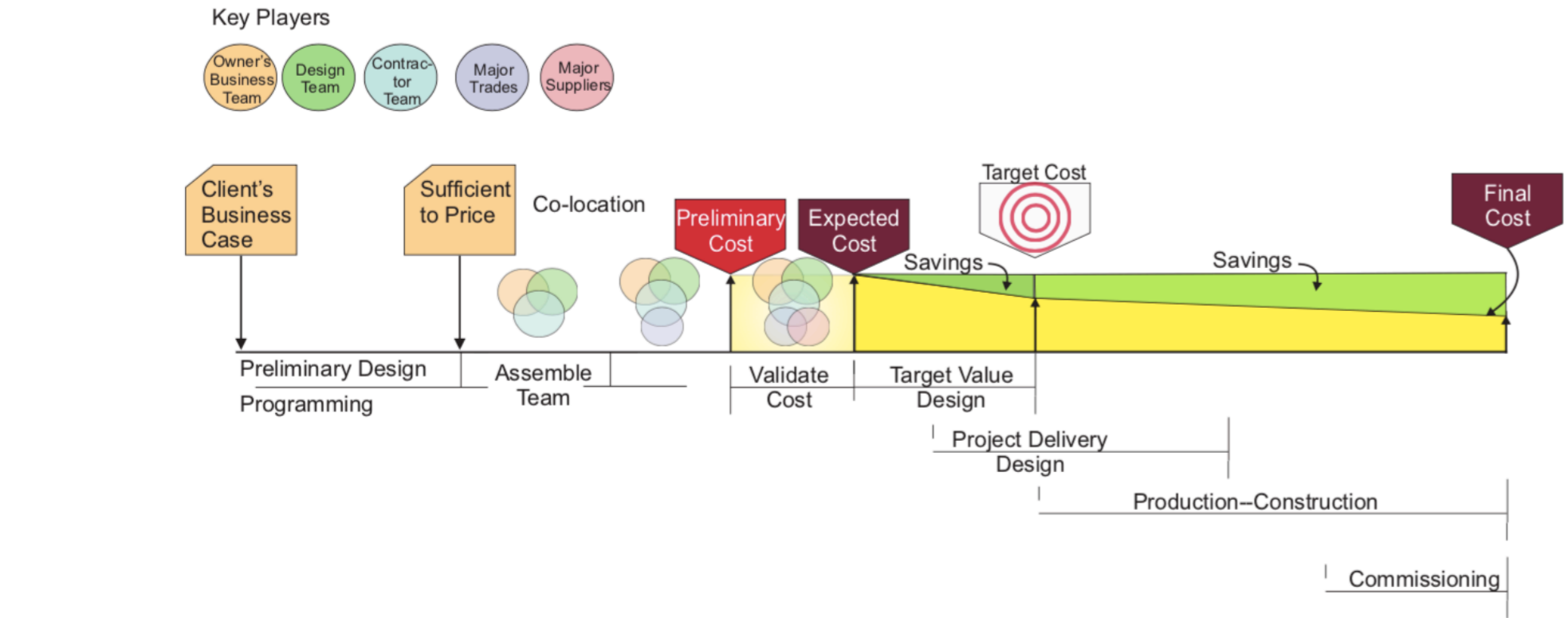


INTEGRATED  
TARGET VALUE DESIGN

Ng, M. S., Bonanomi, M. M., Hall, D. M., & Hackl, J. (2020). "Design for Digital Fabrication: an Industry needs Analysis of Collaboration Platforms and Integrated Management Processes." Proc. of the 37th ISARC, 318–325. Kitakyshu, Japan.  
Ng, M. S., & Hall, D. M. (2019). "Toward Lean Management for Digital Fabrication: a Review of the Shared Practices of Lean, DiMA and DFAB." Proc. 27th Ann. Conf. IGLC 2019, 725–736.  
Job, N., Ng, M.S. & Hall, D.M. (2020). "Opportunities and challenges of Integrated Project Delivery (IPD) in Switzerland". White paper, Accessi <<https://bit.ly/2R285ZP>>.



From Clifton et al, Target Costing: Market-Driven Product Design, figure 5.2, p. 73



© Dick Bayer, 2009; updated March 2, 2011

# STATE-OF-THE-ART

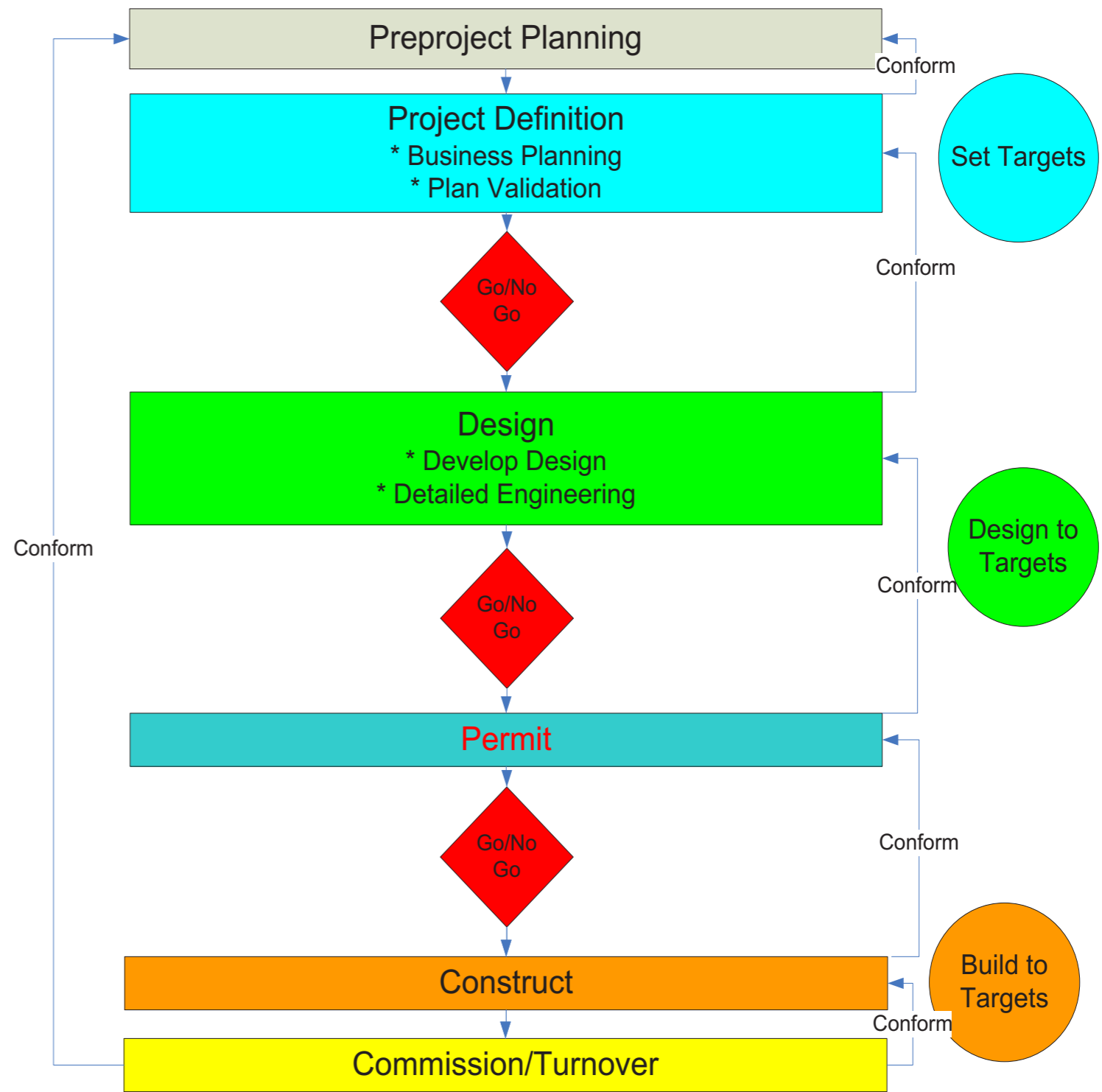
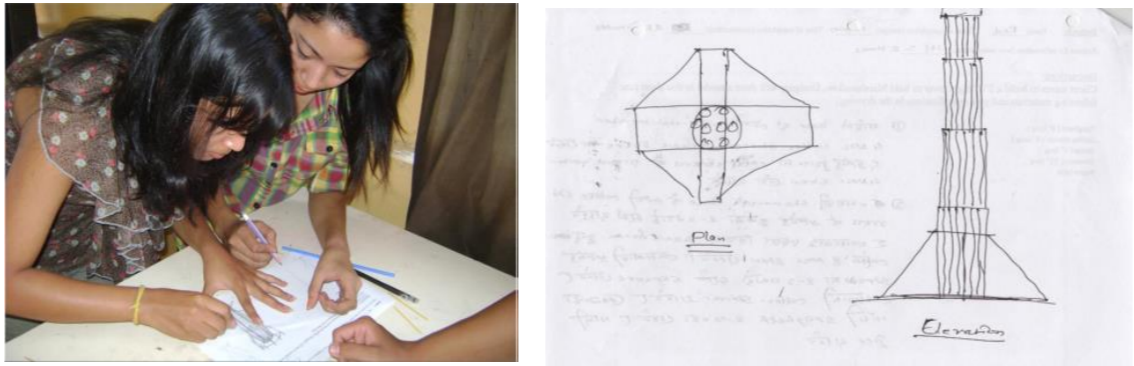


Figure 1: Target Value Design by Project Phase



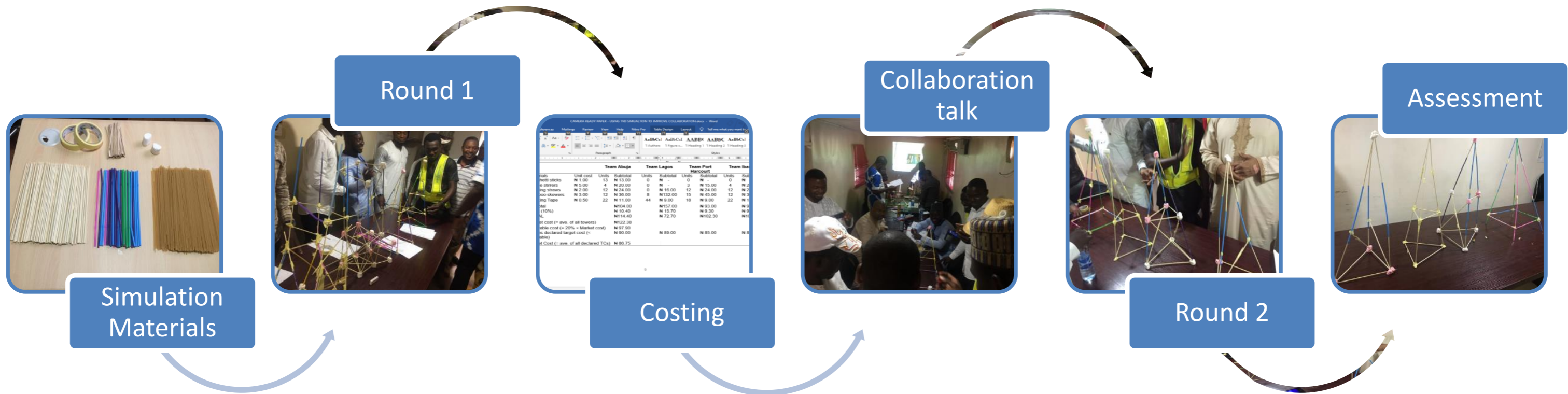
**Figure 2.** Materials required for simulation (Munakami 2012)



**Figure 6.** Round One: Separation of owners, designers and constructors communicated through sketches, requests for information, and change orders (Munankami 2012).

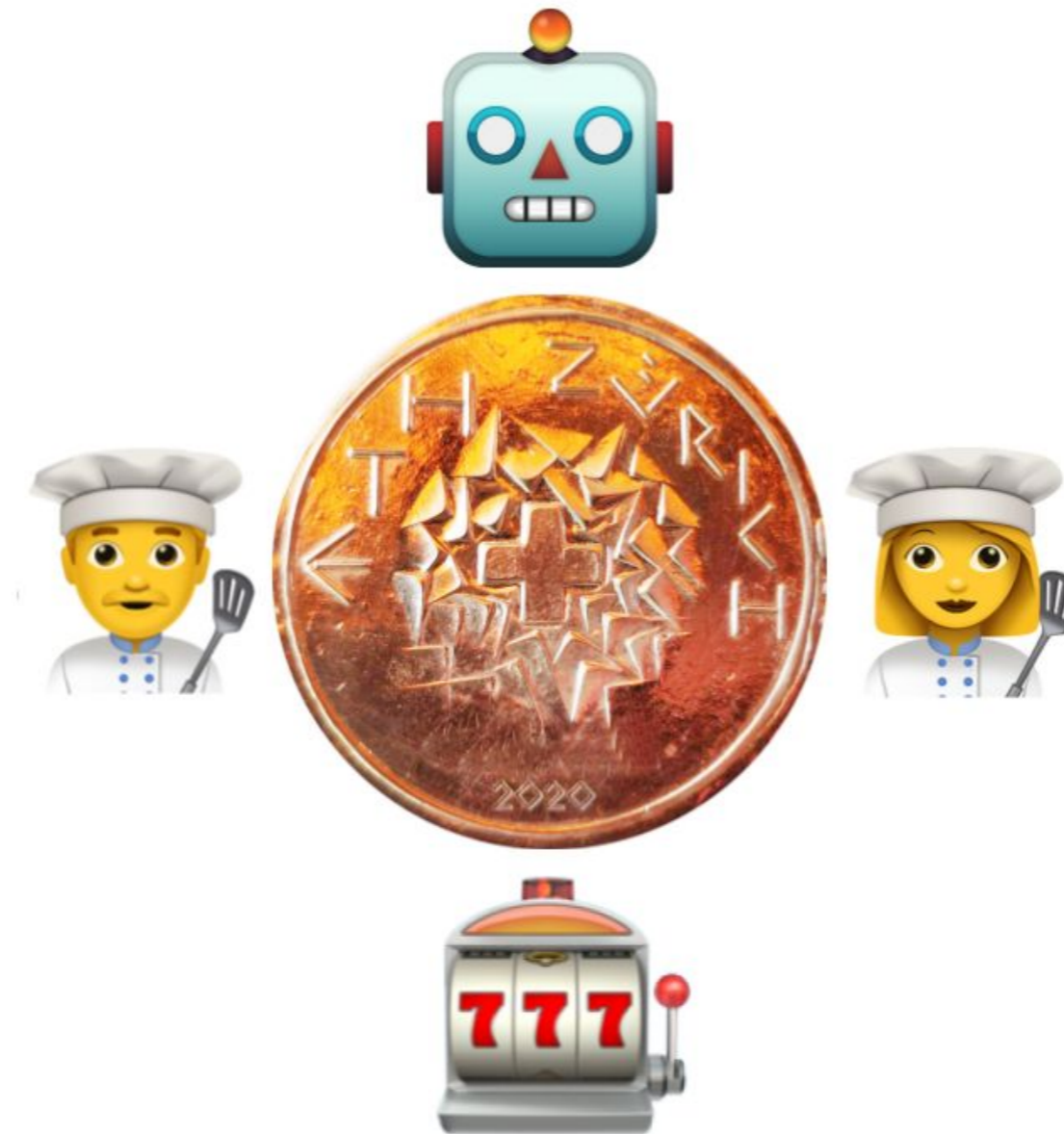


**Figure 7.** Round Two: Once target cost was established, teams co-located and worked collaboratively to re-design the tower to meet target cost (Munankami 2012).





- (1) can reflect the reality of the considerations needed for adoption of DFAB on a construction project.**
- (2) can be played online.**



**ETH** zürich **DBAUG**   Ming Shan Ng  
Prof. Dr. Daniel M. Hall

## TARGET VALUE DESIGN

FOR

**DIGITAL FABRICATION  
ONLINE GAME**



## TODAY: Your team is opening a new 4-star restaurant



**You can choose one of 4 roles...**



## The 4 roles...



**ARTISTIC CHEF**

“**A**” + Your Name

**To play this game**

1. Drag & Drop items on Google Slides.



**RECIPE CHEF**

“**R**” + Your Name

**To play this game**

1. Drag & Drop items on Google Slides.
2. Optimise the weights on Google Sheet



**EXECUTIVE CHEF**

“**E**” + Your Name

**To play this game**

1. Optimise the process and cost on Google Sheet



**RESTAURANT OWNER**

“**O**” + Your Name

**To play this game**

1. Observe and review the design.
2. Provide verbal advices to the team (Round 2 only).



**Your task is to design a new salad...**



**...inspired by**



# Your task is to design a new salad...











## ROUND 1 OBJECTIVE









The customer wants:



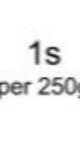
- At least 500g of Salad, the heavier the better
- Artistic Design inspired by The Starry Night
- Equal Balance between Ingredients
- Good Price



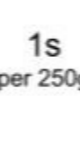


 2.5g  
 12.5g  
 50g  
 25g  
 2.5g  
 10g  
 50g  
 50g

 OR  OR   
**CHF 0.25/s** **CHF 3/s** **CHF 30/s**  
**1s** **N/A** **N/A**  
 per 2.5g

 OR  OR   
**CHF 0.25/s** **CHF 3/s** **CHF 30/s**  
**1s** **N/A** **N/A**  
 per 2.5g


 OR  OR   
**CHF 0.25/s** **CHF 3/s** **CHF 30/s**  
**10s** **1s** **1s**  
 per 10g per 10g per 250g

 OR  OR   
**CHF 0.25/s** **CHF 3/s** **CHF 30/s**  
**40s** **5s** **1s**  
 pe 50g per 50g per 250g

ROUND 1 - GROUP 1									
INGREDIENT	WEIGHT PER PIECE (g)	AMOUNT	WEIGHT (g)	Imbalanced-ness (g)	TOOL			TIME BREAK DOWN (s)	Tool Cost (CHF/s)
CARROT	2.5			Knife (CHF 0.25/s)	Knife	<input type="checkbox"/>	<input type="checkbox"/>		
	5			Hand Spiraliser (CHF 3/s)	Knife	<input type="checkbox"/>	<input type="checkbox"/>		
	12.5			Electric Spiraliser (CHF 30/s)		<input type="checkbox"/>	<input type="checkbox"/>		
	25					<input type="checkbox"/>	<input type="checkbox"/>		
	50			Imbalanced-ness (g)		<input type="checkbox"/>	<input type="checkbox"/>		
CUCUMBER	2.5			Knife (CHF 0.25/s)	Knife	<input type="checkbox"/>	<input type="checkbox"/>		
	5			Hand Spiraliser (CHF 3/s)	Knife	<input type="checkbox"/>	<input type="checkbox"/>		
	10			Electric Spiraliser (CHF 30/s)		<input type="checkbox"/>	<input type="checkbox"/>		
	25					<input type="checkbox"/>	<input type="checkbox"/>		
	50			Imbalanced-ness (g)		<input type="checkbox"/>	<input type="checkbox"/>		
TOMATO	5			Knife (CHF 0.25/s)		<input type="checkbox"/>	<input type="checkbox"/>		
	10			Zip Slicer (CHF 5/s)		<input type="checkbox"/>	<input type="checkbox"/>		
				Imbalanced-ness (g)		<input type="checkbox"/>	<input type="checkbox"/>		
EGG	10			Pot (CHF 0.25/s) Egg Boler (CHF 20/s)		<input type="checkbox"/>	<input type="checkbox"/>		
	15			Knife (CHF 0.25/s) Egg Slicer (CHF 5/s)		<input type="checkbox"/>	<input type="checkbox"/>		
TOTAL									
									ROUND 1
									TOTAL COST YOUR PROFIT


## OPTIONAL TO SELECT

Junior Assistant



s: -25%  
**+1.5 CHF/s**

Senior Assistant



s: -50%  
**+3 CHF/s**

 OR   
**CHF 0.25/s** **CHF 20/s**  
**1s** **1s**  
 per 5g per 250g

+

 OR   
**CHF 0.25/s** **CHF 5/s**  
**1s** **1s**  
 per 5g per 50g

 5g  
 10g  
 10g  
 15g



Table 1: Task details and rundown of in total 15 mins duration in Round 1

Scope of work	Deliverables	Task owner	5 min	10 min	15 min
Layout concept design	The Starry Night	Artistic Chef	SL		View
Weights optimisation	Balanced weights	Recipe Chef	View	SL+SH	View
Process pricing	Good price	Executive Chef	View		SH
Design review	Customer's values	Restaurant Owner	View		View

Table 2: Task details and rundown of in total 15 mins duration in Round 2

Scope of work	Deliverables	Task owner	5 min	10 min	15 min
Layout concept design	The Starry Night	Artistic Chef	SL		
Weights optimisation	Balanced weights	Recipe Chef	SL+SH		
Price optimisation	Good price	Executive Chef	SH		
Design advice	Customer's values	Restaurant Owner	View + Comment		



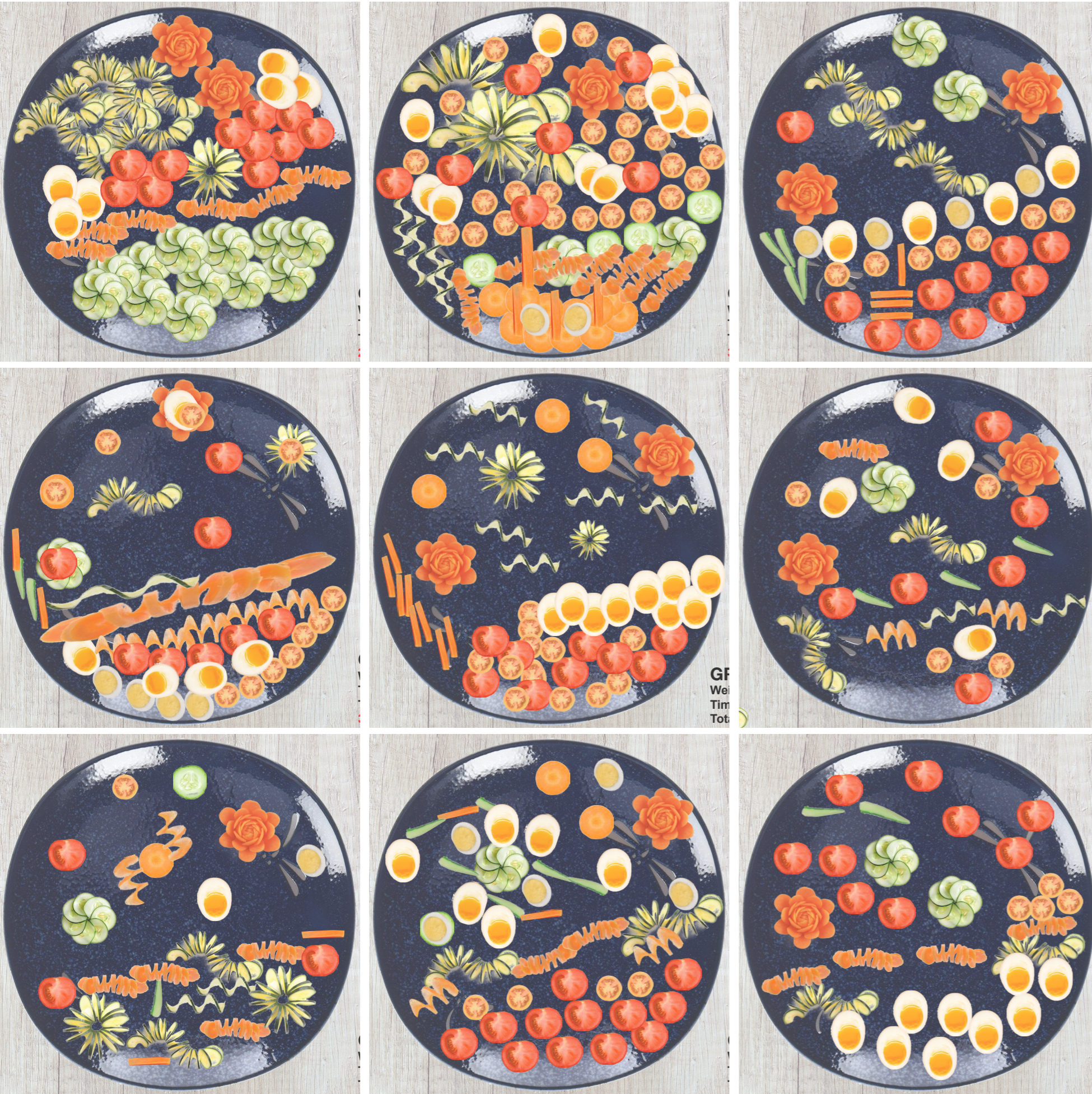
ROUND 1



ROUND 2



## ROUND 1

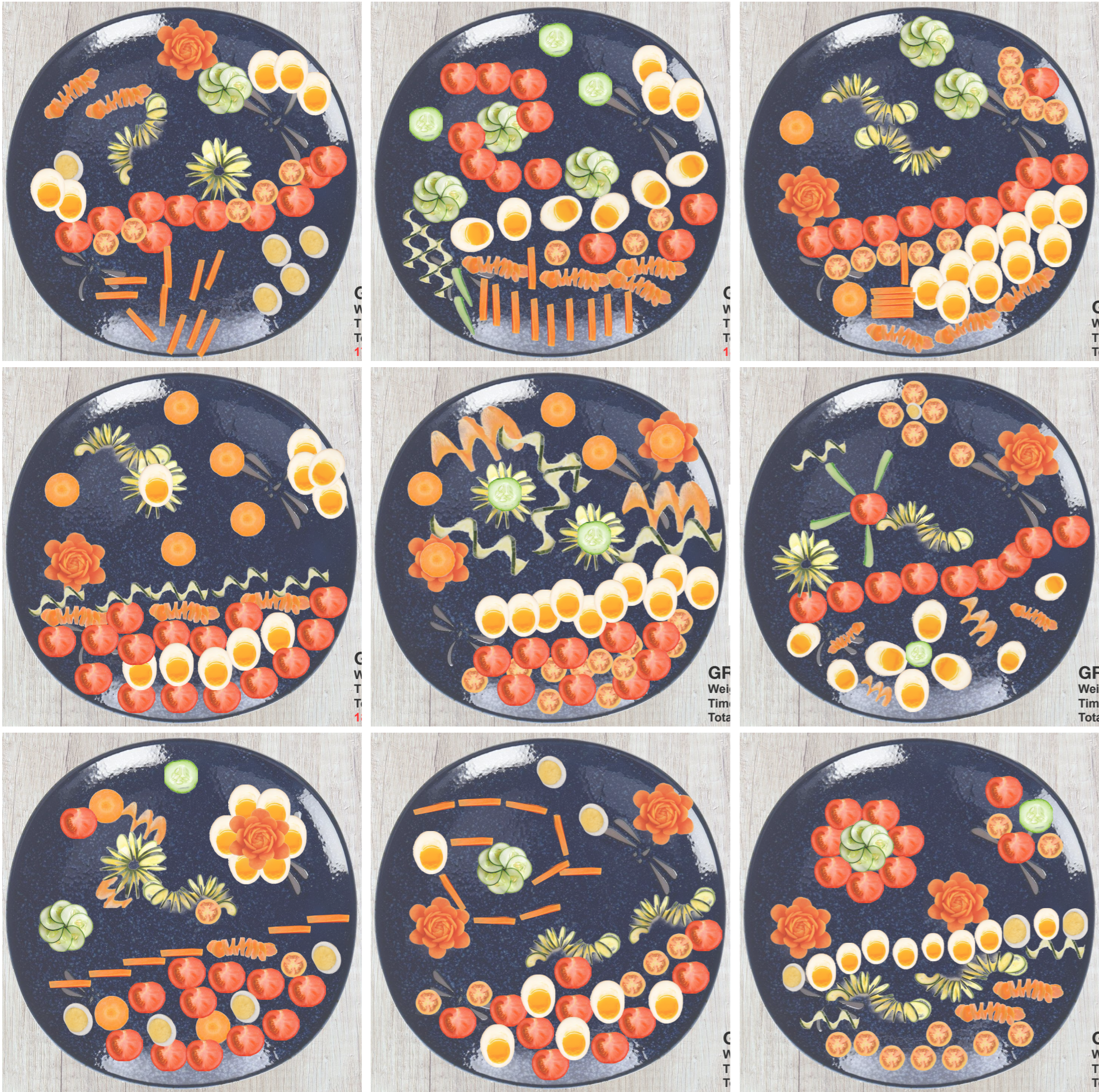


# CASE STUDY RESULTS

## ROUND 1 – DBB approach

Group	Total Cost (CHF)	Profit (CHF)	Total Time (s)	Design approved?
1	217	11	11	×
2	321	16	37	✓
3	160	8	48	✓
4	327	16	78	✓
5	183	9	39	✓
6	167	8	29	✓
7	254	13	60	×
8	194	10	61	✓
9	272	14	172	✓
$\mu$	235	12	66	
$\sigma$	67.8	3.4	45.8	

## ROUND 2



# CASE STUDY RESULTS

21

Ming Shan NG (Charmaine)

## ROUND 2 – TVD approach

Group	Total Cost (CHF)	Profit (CHF)	Total Time (s)	Design approved?
1	176	24	44	✓
2	185	15	36	✓
3	176	24	40	✓
4	192	8	26	✓
5	159	41	31	✓
6	160	40	33	✓
7	160	40	67	✓
8	152	48	28	✓
9	190	10	64	✓
$\mu$	172	28	41	
$\sigma$	15.9	15.9	16.0	

Table 3: The results of ROUND 1 and ROUND 2 in the game's case study.

Group	ROUND 1 – DBB approach				ROUND 2 – TVD approach			
	Total Cost (CHF)	Profit (CHF)	Total Time (s)	Design approved?	Total Cost (CHF)	Profit (CHF)	Total Time (s)	Design approved?
1	217	11	11	×	176	24	44	✓
2	321	16	37	✓	185	15	36	✓
3	160	8	48	✓	176	24	40	✓
4	327	16	78	✓	192	8	26	✓
5	183	9	39	✓	159	41	31	✓
6	167	8	29	✓	160	40	33	✓
7	254	13	60	×	160	40	67	✓
8	194	10	61	✓	152	48	28	✓
9	272	14	172	✓	190	10	64	✓
$\mu$	235	12	66		172	28	41	
$\sigma$	67.8	3.4	45.8		15.9	15.9	16.0	

	ARTISTIC CHEF	RECIPE CHEF	EXECUTIVE CHEF	RESTAURANT OWNER
Scope of work	Salad Layout Design	Recipe Design	Cookability Design	Design Review
IN ROUND 1 OF THIS GAME				
Goal	Mimic the Van Gogh’s painting	Control the weights	Determine process & costs	Ensure customer is satisfied
IN ROUND 2 OF THIS GAME				
Goal	Mimic the Van Gogh’s painting	Control the weights	Optimise process & costs	Ensure customer is satisfied
	ARCHITECT	ENGINEER	CONTRACTOR	CLIENT REPRESENTATIVE
Scope of work	Architectural Design	Engineering Design	Constructability Design	Design Review
IN A CONVENTIONAL DESIGN PROCESS				
Goal	Design to client’s requirements	Make sure the design works	Provide a bid for construction	Ensure client’s goals
IN A TARGET VALUE DESIGN PROCESS				
Goal	Design to client’s requirements	Make sure the design works	Ensure constructability	Ensure client’s target values



IN THIS GAME
Ingredients
Cooking Tools
Tool Capability
Junior Assistant & Senior Assistant
Spiral
Efficiency
At least 500g & Balanced Ingredients
Extra Weight
Weight (g)
Time (s)
Process Cost (CHF)

IN A CONSTRUCTION PROJECT
Building systems/ materials
Construction tools/ machinery
Fabrication information
Different skilled-level Labours
Complex Design
Degree of Automation
Project’s requirements
Building life-cycle return of investment
Design deliverable/ performance
Human-dependency
Fabrication Cost

## POTENTIAL FUTURE RESEARCH

1. To elaborate and include more criteria of the cost elements and design requirements, and can explore how players can undertake a more complex design process in both the DBB and TVD processes, which take not only DFAB process but also material requirements etc. into account.
2. To explore theoretically the use of DFAB in TVD and how this helps to maximise values to stakeholders in construction projects.

## ACKNOWLEDGEMENT

The authors would like to thank Prof. Dr. Zofia Rybkowski, Mr. Alan Mossman and APLSO: Administering and Playing Lean Simulation Group for the feedback on the Alpha version played in early November 2020, and all the players who undertook the Beta version of the game on 7th December 2020 at ETH Zurich in Switzerland for the case study validation.



## MING SHAN (CHARMAINE) NG

ETH Zürich Doctoral Researcher  
JSPS Postdoctoral Fellow

LEED Accredited Professional (BD+C)  
British Chartered Architect RIBA, ARB  
Swiss Registered Architect SIA/ETH

Dipl. Arch ETH  
MSt (University of Cambridge)  
BA (Arch)  
BA (Journalism & Media Studies)

✉ [ng@ibi.baug.ethz.ch](mailto:ng@ibi.baug.ethz.ch)

[www.linkedin.com/in/charmings](https://www.linkedin.com/in/charmings)

**THANK YOU**