

4^{TO} FORO ACADÉMICO BIM COLMAYOR

Gestión y productividad para los proyectos de construcción



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Alcaldía de Medellín
Distrito de
Ciencia, Tecnología e Innovación

Claves para el éxito BIM - Lean

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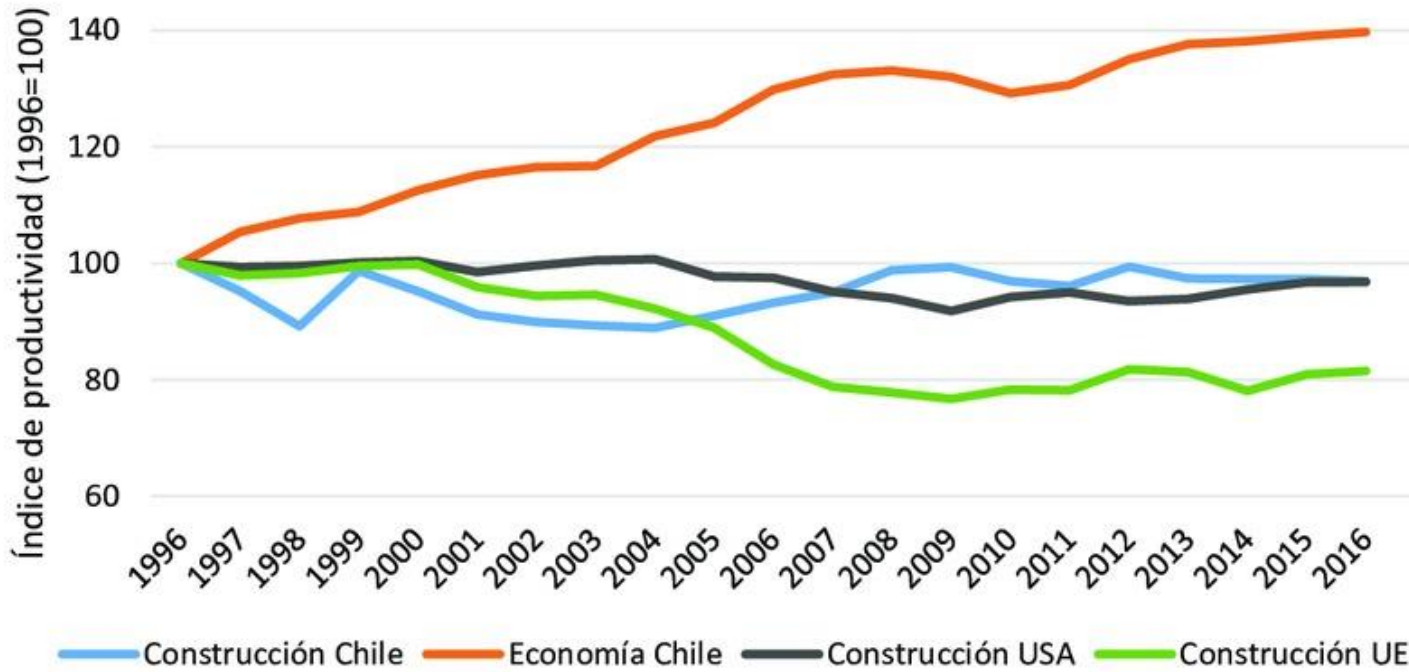


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2. Algunos antecedentes para contextualizar
 - Lean en etapas tempranas
 - BIM en la planificación y diseño
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4. Investigación en 64 proyectos (Chile, Colombia, España)
 5. BIM y Lean ¿necesario o suficiente?
6. Impacto de Lean y BIM en los equipos de trabajo

Preámbulo

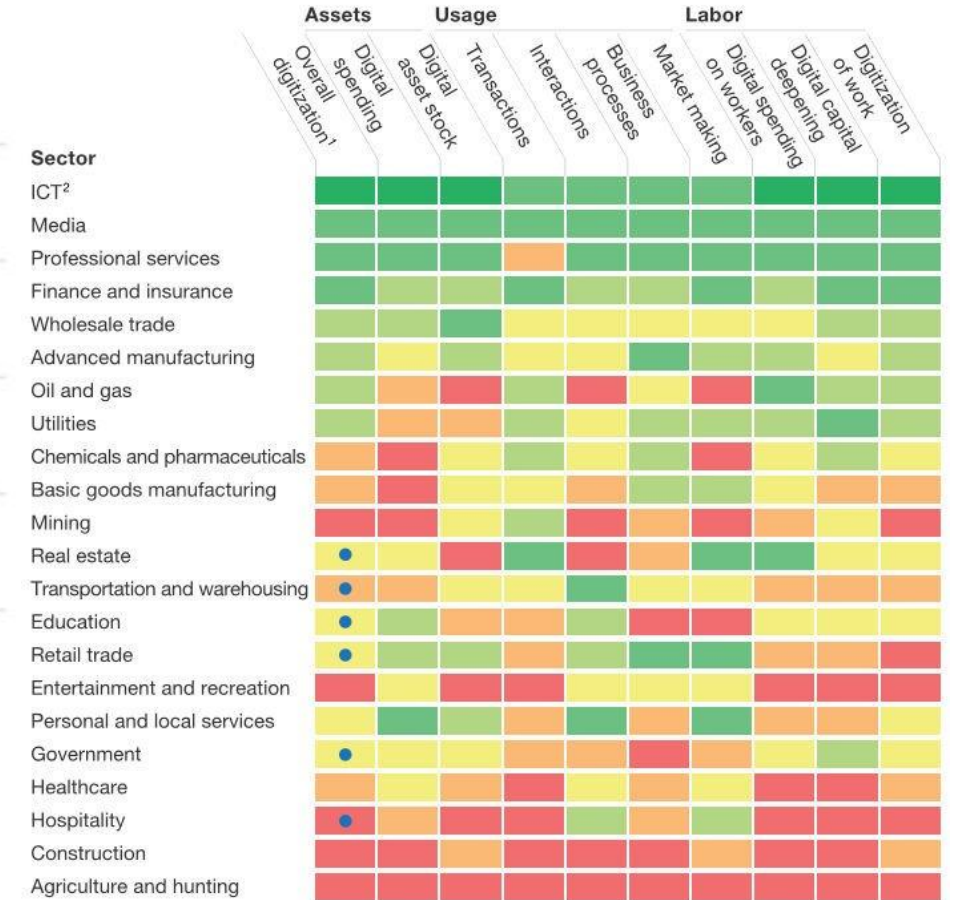


The construction industry is among the least digitized.

McKinsey Global Institute industry digitization index; 2015 or latest available data

Relatively low digitization ■ ■ ■ ■ Relatively high digitization

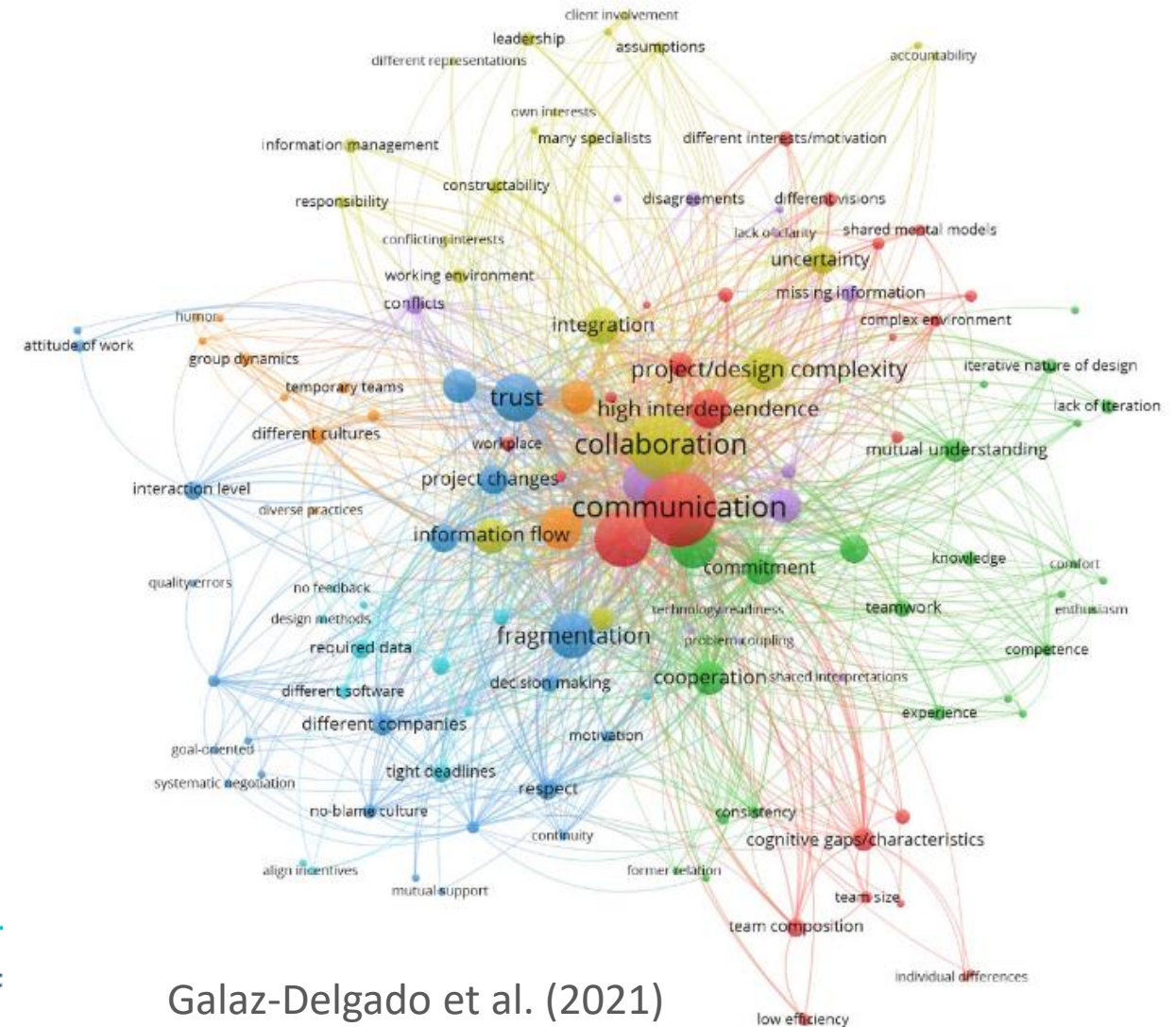
● Digital leaders within relatively undigitized sectors



Preámbulo

PROBLEMAS Y DESAFÍOS EN LAS INTERACCIONES DE LOS EQUIPOS DE DISEÑO DE PROYECTOS DE CONSTRUCCIÓN

n	Main Problems	Average Year of Publication	Occurrences	Links	Total Link Strength
1	communication	2015	70	124	569
2	collaboration	2015	56	109	487
3	coordination	2015	41	103	369
4	trust	2015	30	95	300
5	information exchange	2015	28	77	238
6	fragmentation	2016	27	81	261
7	identification of roles	2016	26	89	263
8	project/design complexity	2015	24	74	211
9	no colocation	2014	23	79	221
10	high interdependence	2016	19	72	199
11	integration	2015	17	64	177
12	information flow	2014	16	56	134
13	cooperation	2013	15	59	155
14	knowledge exchange	2014	15	47	110
15	shared understanding	2016	15	57	133
16	team cohesion	2016	14	67	154
17	commitment	2014	13	70	174
18	project changes	2016	11	60	132
19	multiple disciplines	2016	10	50	112
20	transparency	2015	10	46	95
21	uncertainty	2016	10	52	102



Galaz-Delgado et al. (2021)

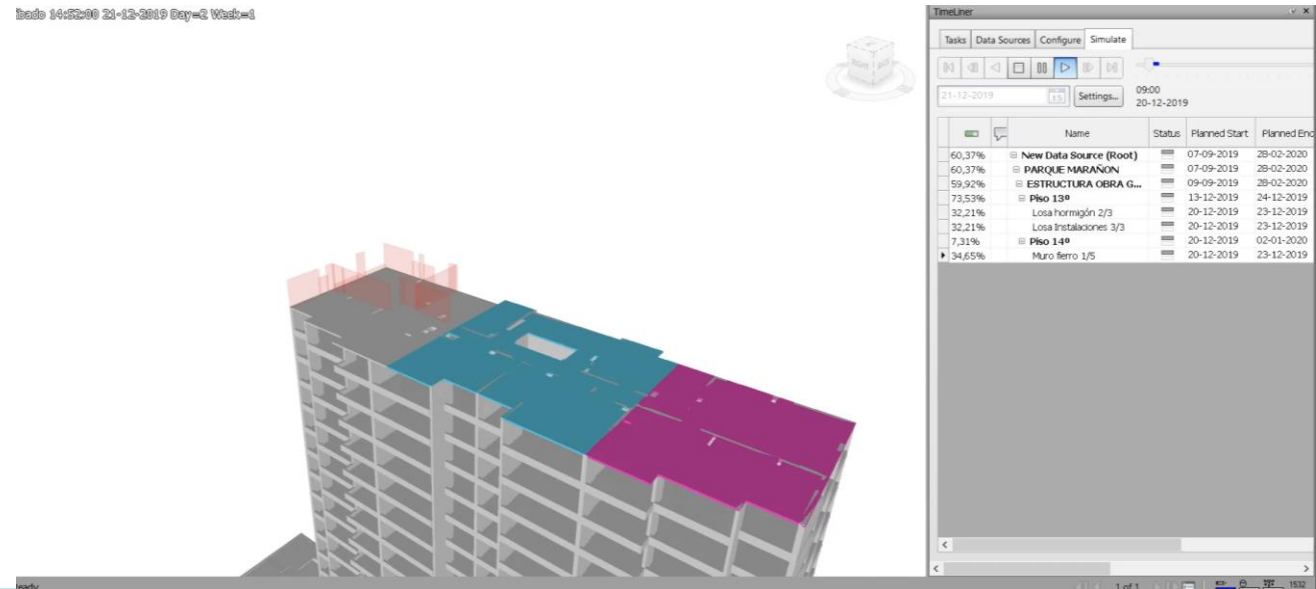
Lean en el diseño Gestión de interesados

Herrera et al. (2020)

- SM₁ Specialist designers are involved during early stages of the project.
- SM₂ Builders are involved during early stages of the project.
- SM₃ The identification of requirements of the stakeholders is exhaustive, in which requirements, constraints, technical specifications and special requirements are defined.
- SM₄ The participation of clients in the design phase involves the systematic participation and support during meetings concerning decision making and resolution of problems.
- SM₅ The design of the product and the construction process are carried out simultaneously.



Isode 14:52:00 21-12-2019 Day=3 Week=4



Lean en el diseño Planificación y Control

Herrera et al. (2020)

PC₁

Project planning considers delivery dates, phases, milestones, task subdivision programs, and control instances. All of these, immersed in a scheme in which gaps, buffers, and points are clarified, can be used to perform pull/push actions within the program.

PC₂

With regard to project planning, this is considered to be information about internal and/or external projects of the organization, generated through a benchmarking exercise.

PC₃

Project planning is conducted collaboratively among various stakeholders.

PC₄

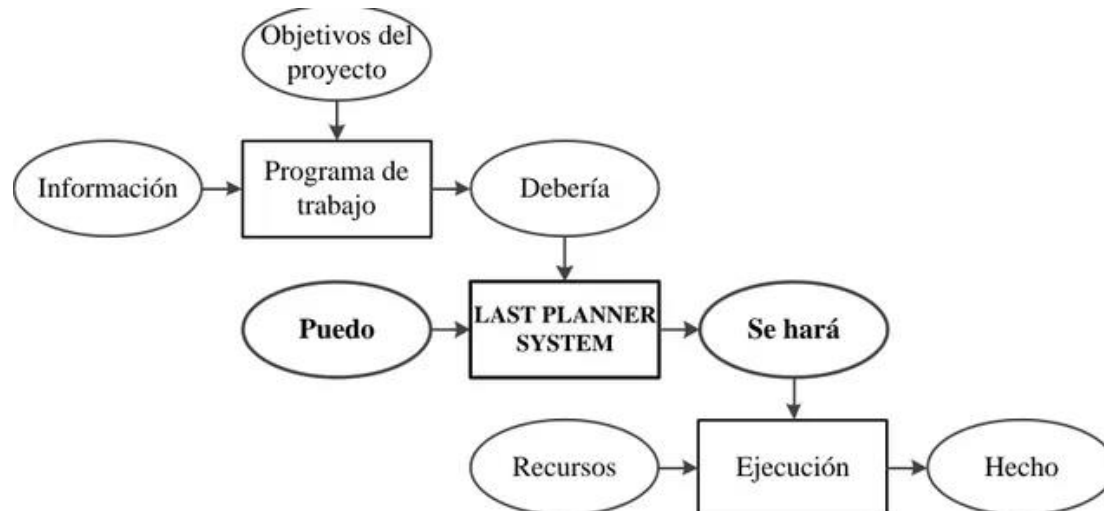
Project planning is carried out at different levels (global, phase, intermediate, and weekly).

PC₅

The constraints in the design process are identified and registered collaboratively and released by a responsible person. Then the constraints are followed.

PC₆

The coordination of project information between the different stakeholders is performed through a single platform, which allows systematic updates and continuous communication between stakeholders.



Lean en el diseño Toma de decisiones

Herrera et al. (2020)

DM₁

There is a protocol to solve problems collaboratively.

DM₂

The last planner identifies the problem and performs a causal analysis (e.g., the 5 Whys method).

DM₃

The solution to the problem is implemented, monitored, and documented to verify that the problem was solved.

DM₄

In the decision-making process, options are evaluated, designed, and tested, and the results are validated and applied.

DM₅

The moment to make decisions is the last responsible moment, and all the information that could be gathered at that moment is used.

DM₆

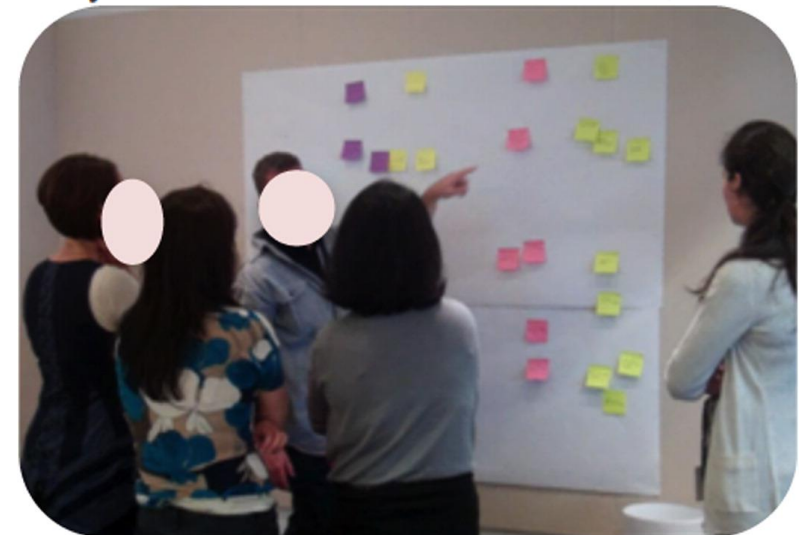
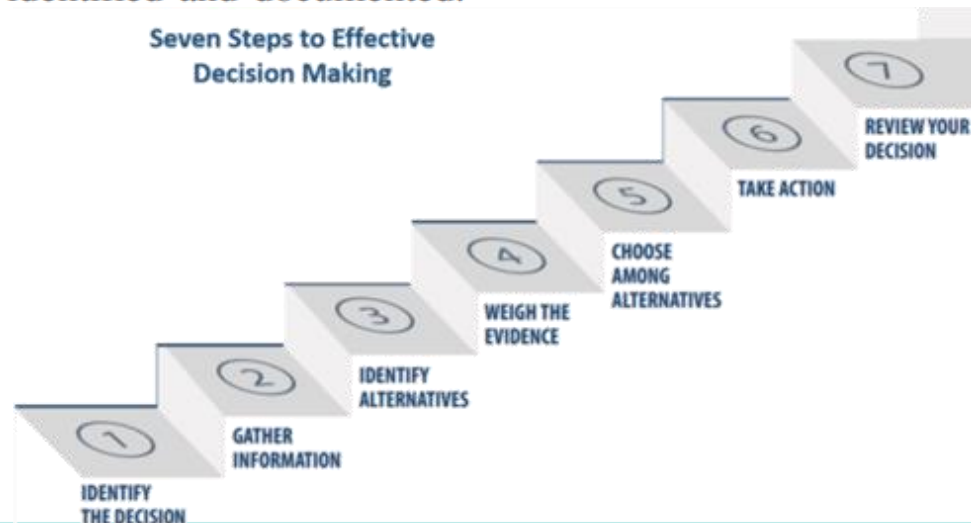
To make decisions, information of internal and/or external projects of the organization is used, generated through a benchmarking exercise.

DM₇

The decision-making mechanism is a meeting with all stakeholders involved, in which a specific technique is used, for example, Choosing by Advantages or others.

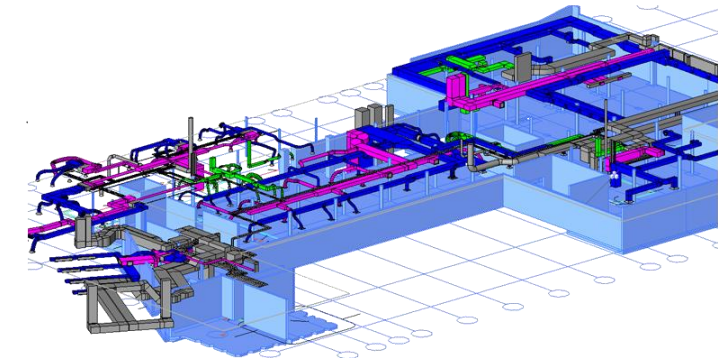
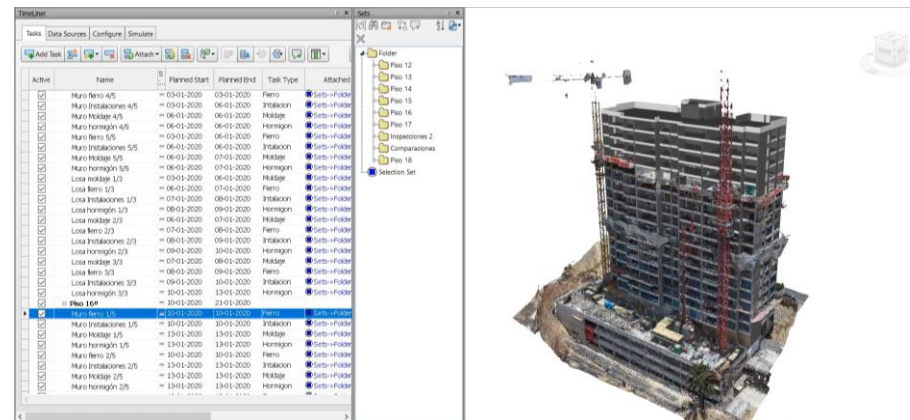
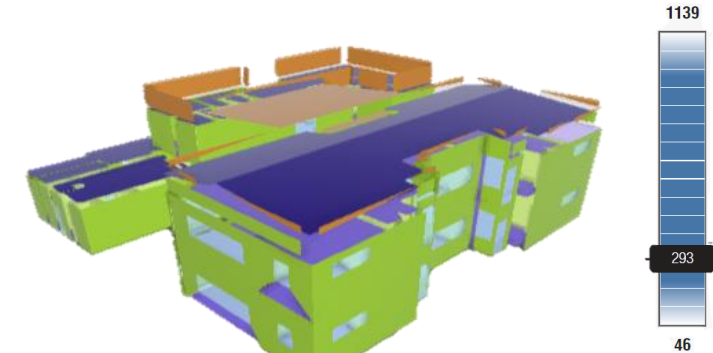
DM₈

After making the decision, specific actions are taken to verify whether satisfactory results were obtained. In addition, the lessons learned are identified and documented.



BIM: Pre-Construcción

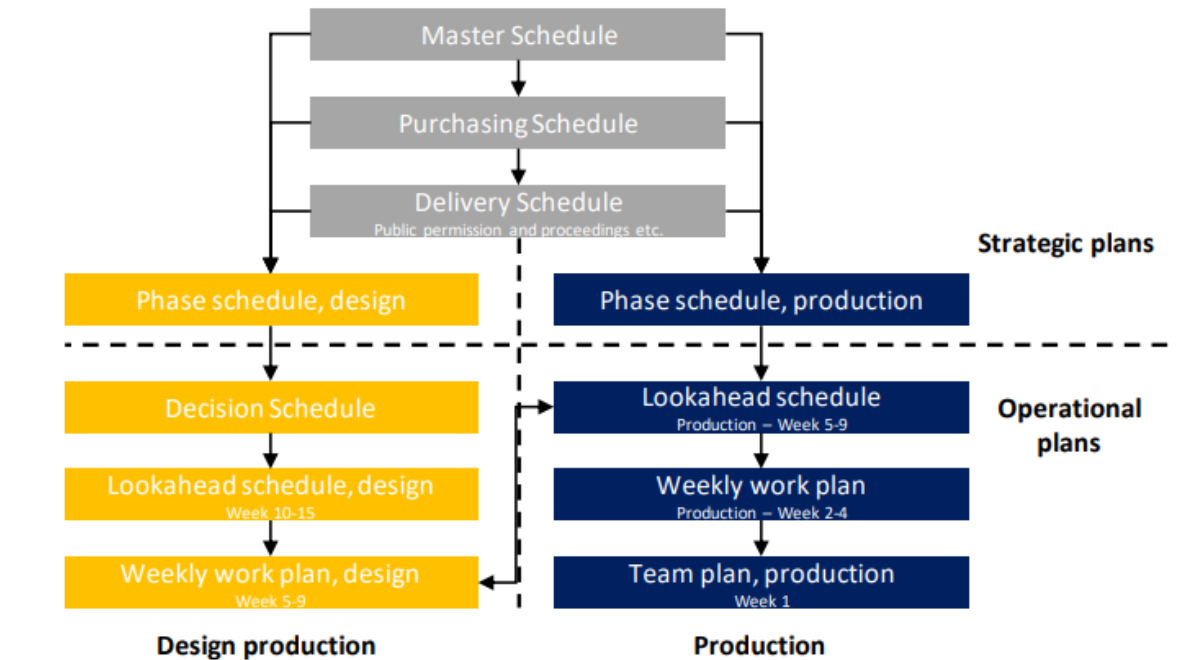
ID	Use
U ₁	Cost estimation
U ₂	4D planning
U ₃	Site analysis
U ₄	Space programming
U ₅	Design review
U ₆	Code validation
U ₇	Sustainability evaluation
U ₈	Engineering analysis
U ₉	Design authoring
U ₁₀	3D coordination



Source: Data from Rojas et al. (2019).

Herramientas Lean – Diseño

Last Planner System



Plan Week		-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
Design	Lookahead schedule	x	x	x	x	x	x	(x)									
	Weekly work plan							x	x	x	x	x					
Production	Lookahead schedule							x	x	x	x	x	(x)				
	Weekly work plan												x	x	x		
	Team plan														(x)	x	

Timeline markers at the bottom: **Only sound activities** (Weeks -15 to -5), **Design completed** (Week -5), and **Construction start-up** (Week -4).

Bolviken et al. (2010)

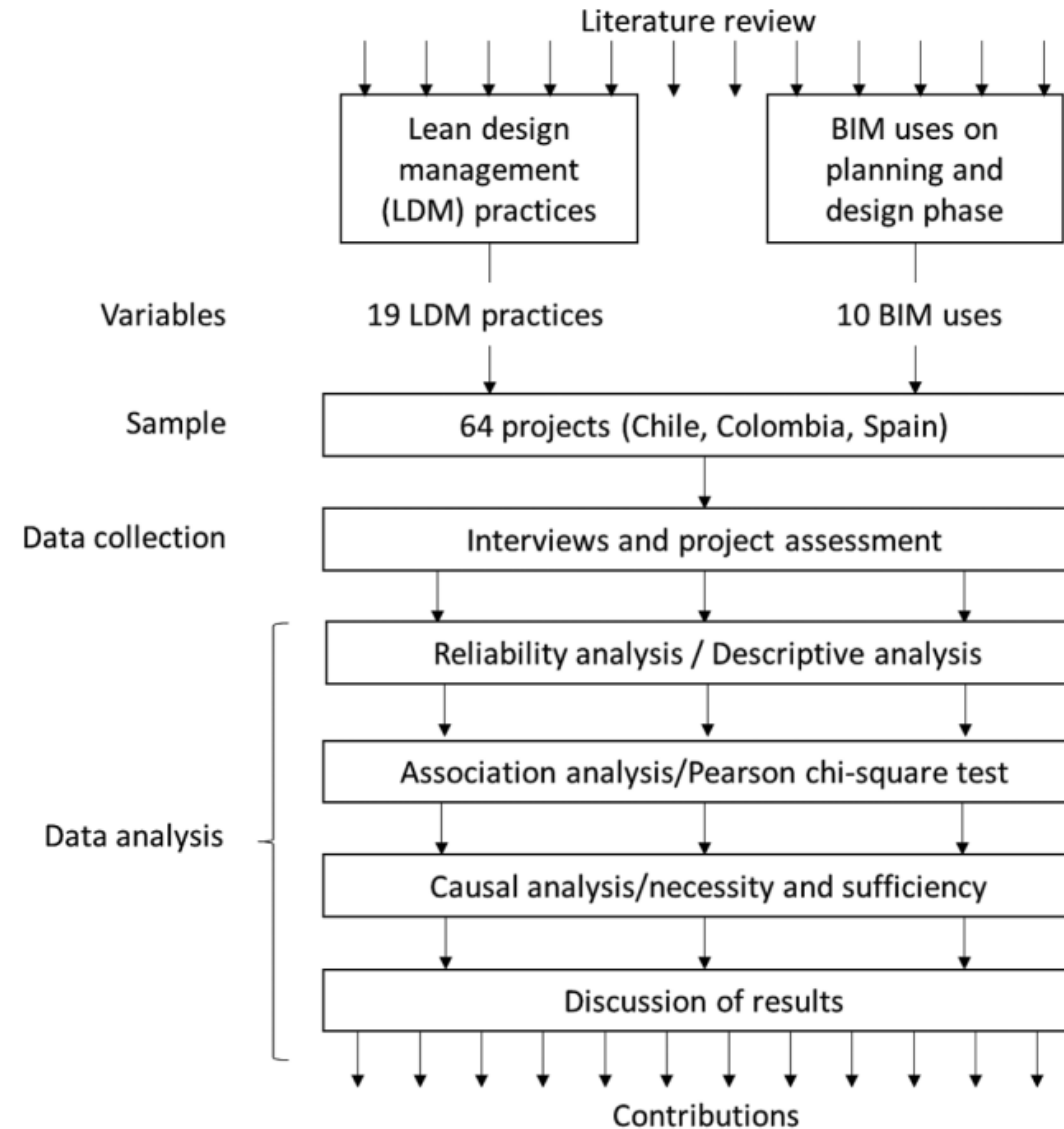
Herramientas Lean en el diseño

<i>Tool/Practice</i>	<i>Description</i>
Target Value Design (TVD) (Ballard, 2011; Lee, 2012; Macomber et al., 2012; Zimina et al., 2012)	It uses the client's requirements to generate value by design, while continuously improve and reduce wastes in project development.
Set-based design (SBD) (Lee et al., 2012; Parrish et al., 2007; Sobek et al., 1999; Ward et al., 1995)	Designers develop integrated design solutions for different criteria considering schedule and budget that will be narrowed collectively until a satisfactory solution.
Choosing by Advantage (CBA) (Arroyo et al., 2015; Arroyo, Tommelein, & Ballard, 2016; Parrish & Tommelein, 2009; Suhr, 1999)	Improves the decision-making process, aligning criteria to evaluate design alternatives, promoting consensus.

Biotto (2019)

<i>Tool/Practice</i>	<i>Description</i>
Agile Design Management (Demir & Theis, 2016)	Agile applied in the design management to embrace changes and add value for designers and client.
Design Structure Matrix (DSM) (Browning, 2001; Eppinger & Browning, 2012; Koskela et al., 1997; Tuholski & Tommelein, 2008)	It is a network modelling tool that visually represents elements of a system and their interactions, and it supports its decomposition and integration of problems.
Last Planner System in Design (Ballard, 1999a; Bolviken et al., 2010; Khan & Tzortzopoulos, 2015; Koskela et al., 1997; Tzortzopoulos et al., 2001; Wesz et al., 2013)	LPS applied in the design stage to increase the design process transparency, designers' collaboration and communication. It improves workflow stability and reliability.

Investigación



Herrera et al. (2021)

Investigación

Table 3. BIM levels

Level	General description
1	Traditional methods [two-dimensional (2D) model].
2	Low use of BIM and little information in the model.
3	Medium use of BIM and sufficient information for BIM.
4	High use of BIM.
5	Full use of BIM. The best tools are utilized to realize all its applications.

Table 4. Summary of project characteristics

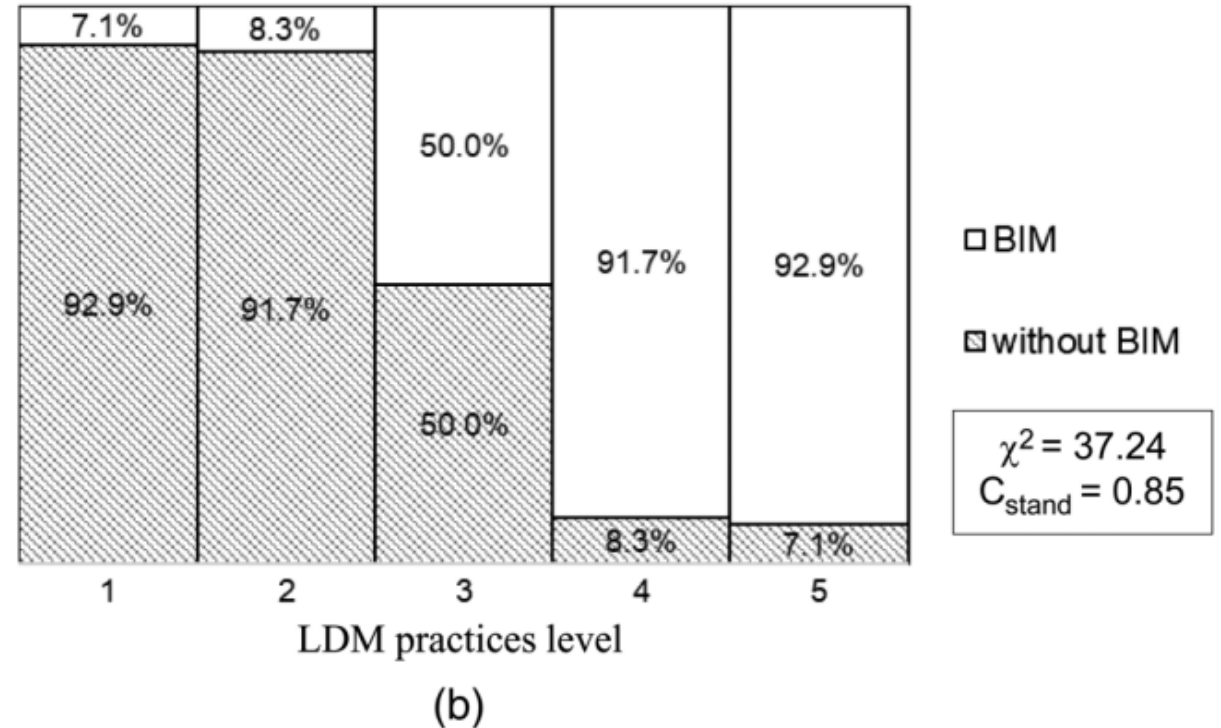
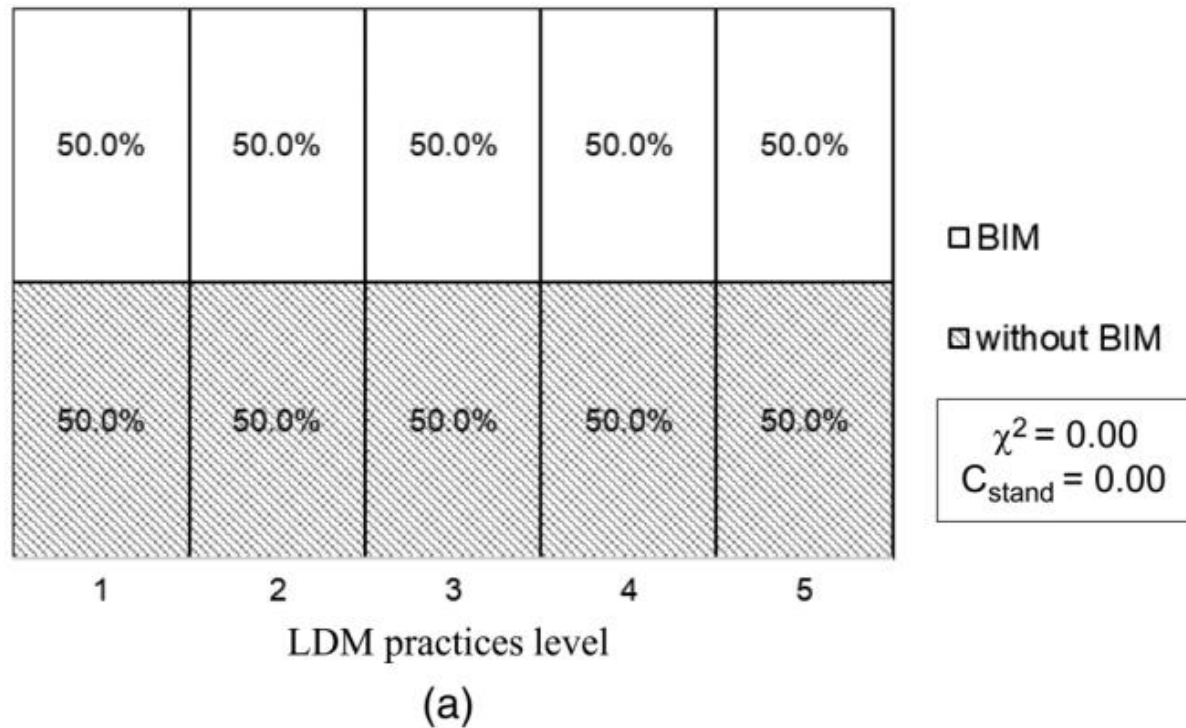
Country	Building project	Infrastructure project	Total
Colombia	12	2	14
Chile	20	12	32
Spain	12	6	18
Total	44	20	64

Table 5. Level of association according to standardized contingency coefficient

C_{stand}	Level of association
+0.70 or higher	Very strong relationship
0.40–0.69	Strong relationship
0.30–0.39	Moderate relationship
0.20–0.29	Weak relationship
0.01–0.19	No or negligible relationship
0.00	No relationship

Herrera et al. (2021)

Investigación



Herrera et al. (2021)

Lean el diseño

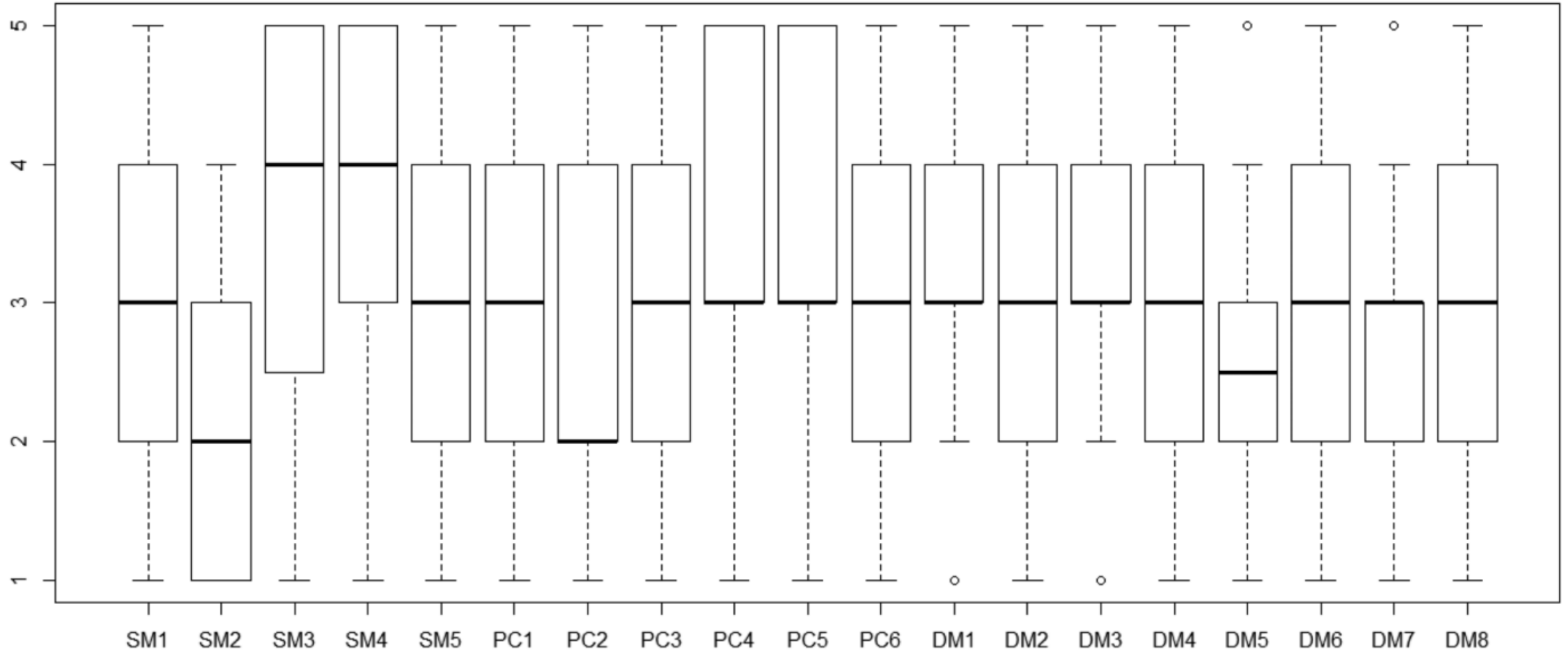


Fig. 3. LDM practices assessment. (Data from Herrera et al. 2020.)

BIM: Pre-Construcción

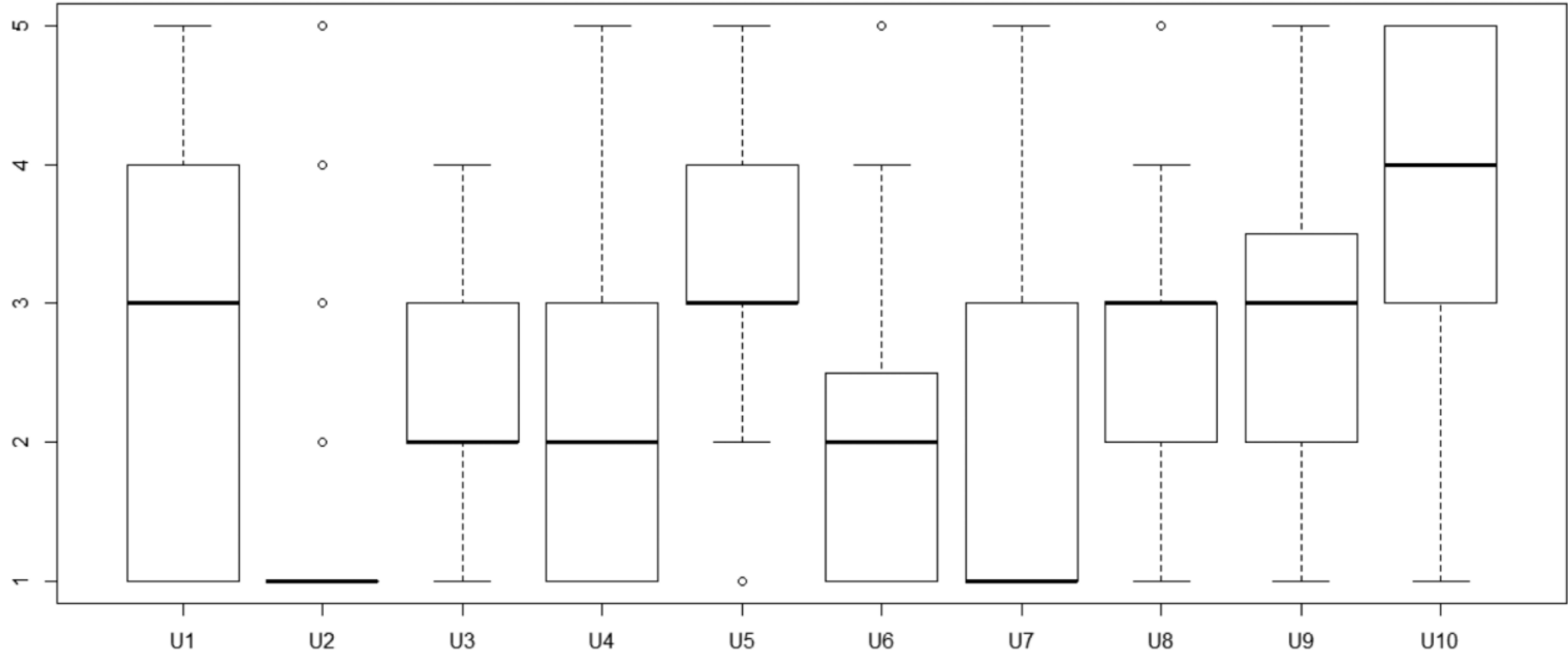


Fig. 4. BIM uses assessment.

Asociación Lean + BIM

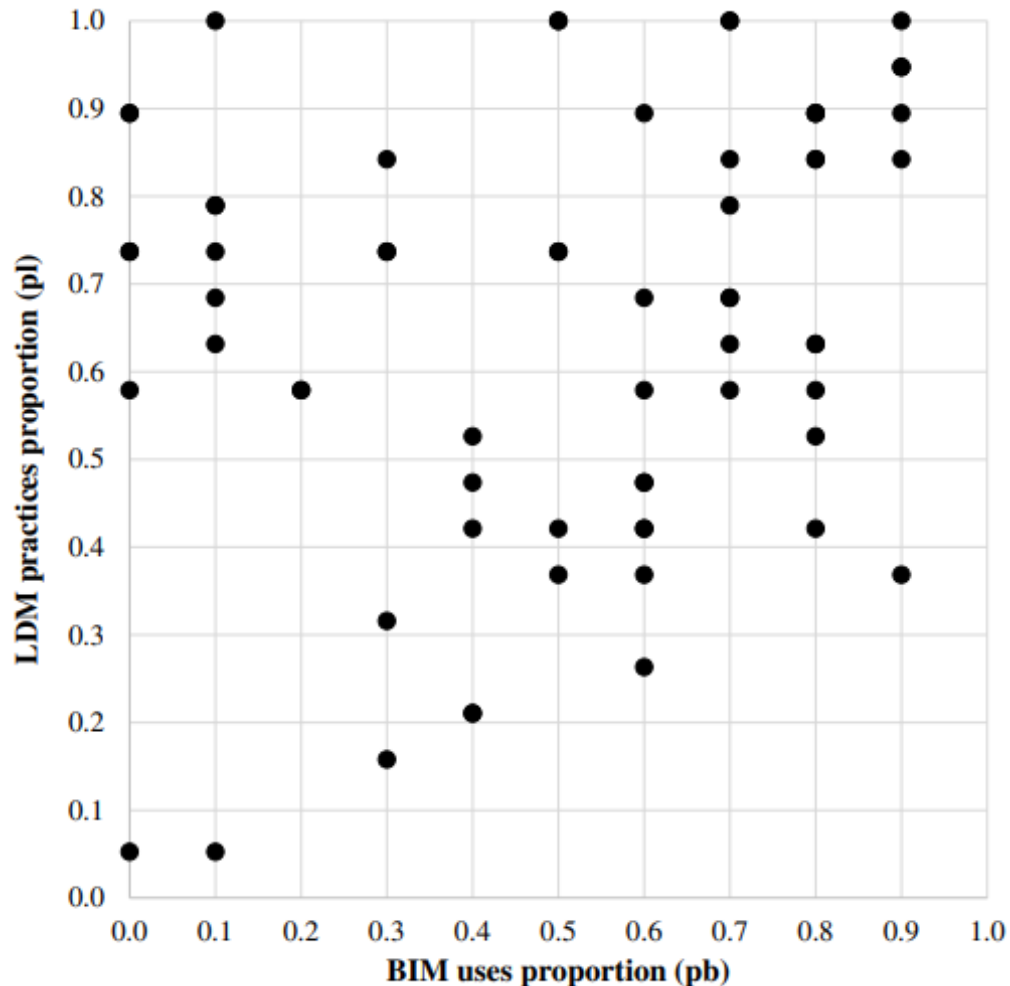


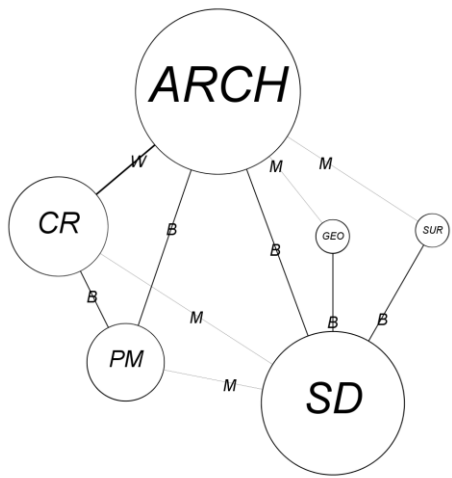
Table 7. Consistency score between p_b and p_l

Condition	Outcome	Necessity	Sufficiency
p_l	p_b	0.8738	0.6733
p_b	p_l	0.6733	0.8748

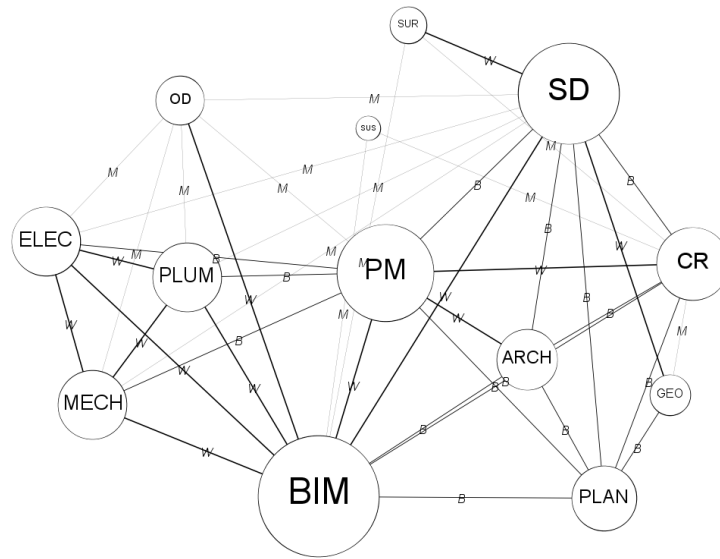
Lean es una condición necesaria para tener un alto nivel de desarrollo BIM, pero no es condición suficiente.

Herrera et al. (2021)

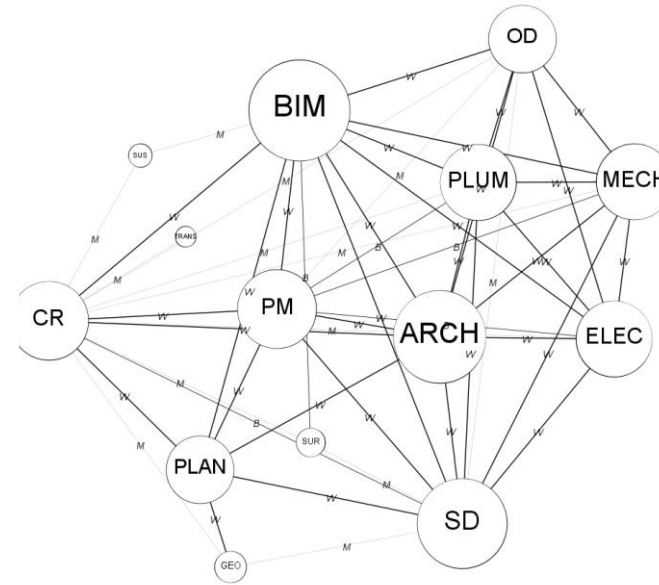
Colaboración en el diseño



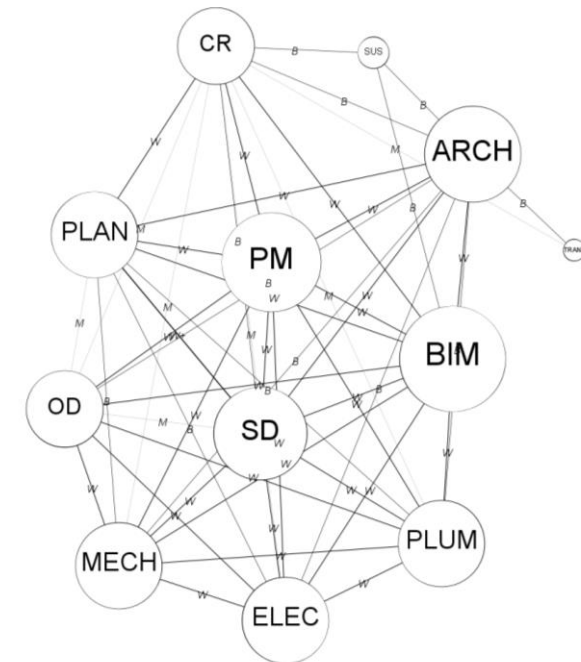
DISEÑO CONCEPTUAL



DISEÑO ANTEPROYECTO



DISEÑO BÁSICO



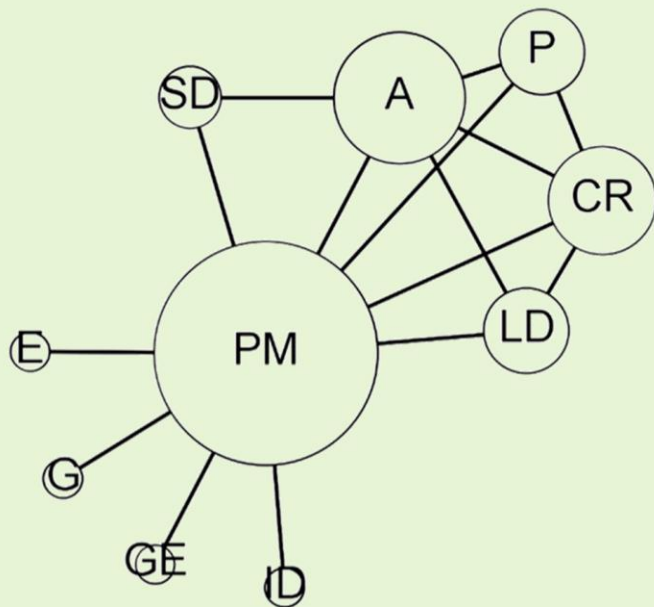
DISEÑO DETALLE

Galaz-Delgado et al. (2021)

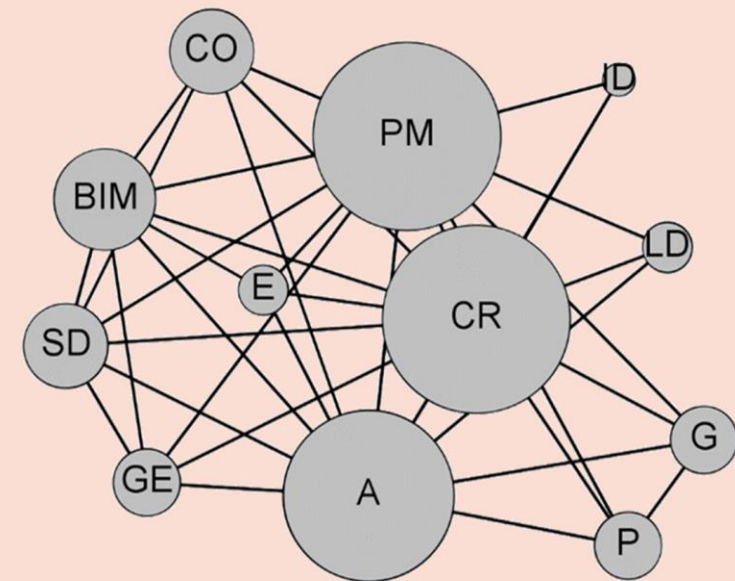
Colaboración en el diseño

Interacción

Proyecto A (tradicional)



Proyecto B (BIM/Lean)

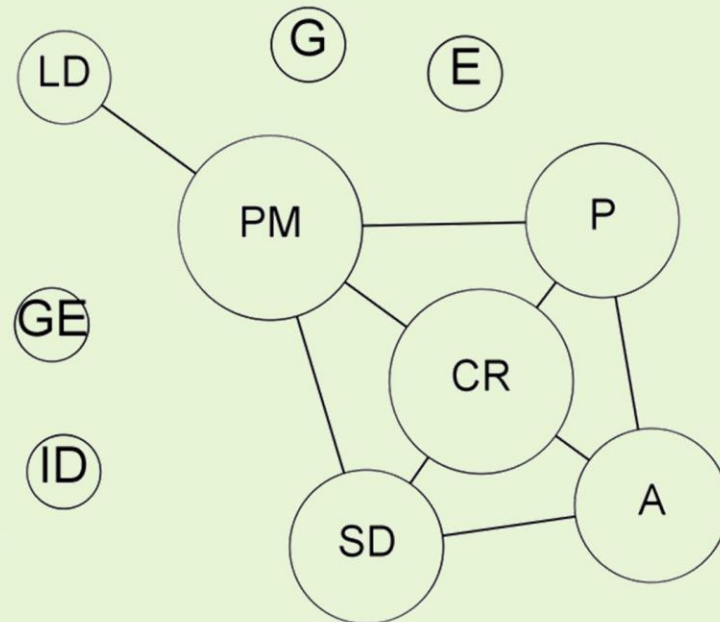


Herrera et al. (2021)

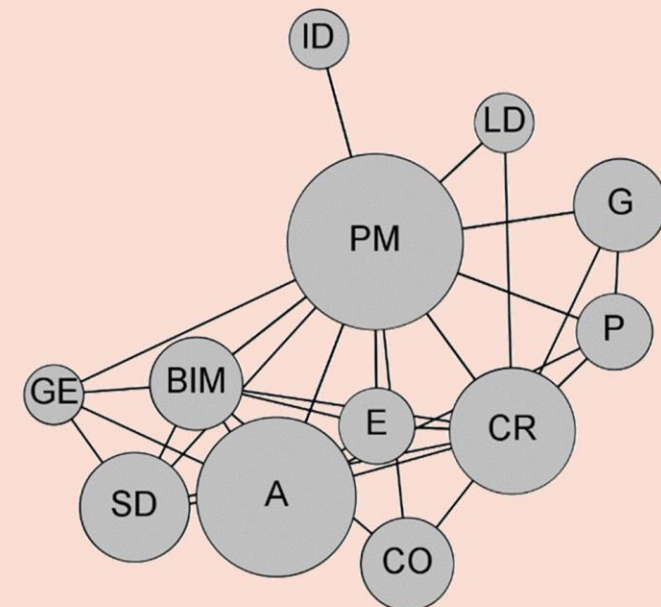
Colaboración en el diseño

Colaboración

Proyecto A (tradicional)



Proyecto B (BIM/Lean)



Herrera et al. (2021)

Claves para el éxito BIM + Lean

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