

Fabricating (Other) Computations: Digital Fabrication and Technological Appropriation in Latin America

Fabricando (otras) computaciones: Fabricación digital y apropiación tecnológica en América Latina

Recibido: 15 de abril de 2019. Aprobado: 16 de septiembre de 2019
Artículo de Investigación

Cómo citar: Sperling, David M., Pablo C. Herrera y Rodrigo Scheeren. "Fabricating (Other) Computations: Digital Fabrication and Technological Appropriation in Latin America".

Dearq n.º 27 (2020): 76-87. DOI: <https://doi.org/10.18389/dearq27.2020.06>

Abstract

This paper introduces and examines the latest and current background of digital fabrication in the context of Latin American architecture and presents updated information from the Homo Faber: Digital Fabrication in Latin America Project, which focuses on laboratories exploring the application of manufacturing technologies in architectural experiments and design objects. The results point to a context including several dynamics involving the emergence of digital craft in communities, the redesign of standard building components, the creation of mobile laboratories, experiments connecting low and high technologies, hacking practices, as well as bottom-up strategies to implement these technologies in the industry. The overall conclusion is that technology transfer and technological appropriation processes are still being carried out in the region.

Keywords: Digital Fabrication, Fabrication Laboratories, Technological Appropriation, Architectural Design, Design Practice, Latin America

Resumen

Este documento presenta y examina los antecedentes más recientes y actuales de la fabricación digital en el contexto de la arquitectura latinoamericana y presenta información actualizada del Proyecto Homo Faber: Fabricación Digital en América Latina. Este proyecto se centra en los laboratorios que exploran la aplicación de las tecnologías de fabricación en experimentos arquitectónicos y objetos de diseño. Los resultados apuntan a un contexto que incluye varias dinámicas que implican el surgimiento de la artesanía digital en las comunidades, el rediseño de componentes de construcción estándar, la creación de laboratorios móviles, experimentos que conectan tecnologías bajas y altas, prácticas de hackeo informático, así como estrategias ascendentes para aplicar estas tecnologías en la industria. La conclusión general es que los procesos de transferencia y apropiación de tecnología se siguen realizando en la región.

Palabras clave: Fabricación digital, laboratorios de fabricación, apropiación tecnológica, diseño arquitectónico, práctica de diseño, América Latina

David M. Sperling

Institute of Architecture and Urbanism - University of São Paulo

✉ sperling@sc.usp.br**Pablo C. Herrera**

Universidad Peruana de Ciencias Aplicadas

✉ pablo.herrera@upc.edu.pe**Rodrigo Scheeren**

Institute of Architecture and Urbanism - University of São Paulo

✉ rodrigoscheeren@gmail.com**Introduction: Towards the “Other”**

In order to understand the context of computation and digital fabrication in Latin American architecture, we must look both inwards and outwards. The procedure involves recognizing part of their own structural conditions, and how they stand regarding the cultural and technological dynamics of globalization. From our region, the action of thinking about the “other” has some antecedents: the theoretical discussion about the identities of the Latin American architecture in the 1990s and the late advances on decolonial theories.

In terms of architecture, the discussion was based on alternative views of the concept proposed by Kenneth Frampton¹ called “critical regionalism”. The author sought to name acts of resistance to universal modernism through synthesizing modern architecture, local architectural, and cultural identities and emphasizing the geographical con-

text, the climate, and tectonic characteristics. In this debate, theorists such as Ramón Gutiérrez,² Cristian Fernandez Cox,³ Marina Waisman,⁴ and Jorge Francisco Liernur,⁵ as well as designers including Gui Bonsiepe,⁶ focused the debate on the unsatisfactory representation of binomial concepts such as center and periphery, the spirit of time and identity of a place, avant-garde, and backwardness as bases to analyze the Latin American architectural and cultural context.

Since that moment until now, decolonial theories have achieved prominence, not only in cultural studies⁷ and aesthetics,⁸ but also in technology.⁹ From this perspective, terms such as “Epistemologies of the South”¹⁰ and “global South”¹¹ have been formulated to nominate projects regarding other narratives in the context of globalized capitalism.

1. Kenneth Frampton. “Towards a Critical Regionalism: Six Points for an Architecture of Resistance,” in *The Anti-Aesthetic. Essays on Postmodern Culture* (Seattle: Bay Press, 1983), 16-30.
2. Ramón Gutiérrez, *Arquitectura Latino-americana: textos para reflexión e polémica* (São Paulo: Nobel, 1989).
3. Cristian Fernandez Cox. “Modernidad Apropriada, Modernidad Revisada y Modernidad Reencantada.” in *Modernidad y Postmodernidad en América Latina* (Bogotá: Escala, 1991).
4. Marina Waisman, *La arquitectura descentrada* (Bogotá: Escala, 1995).
5. Jorge Liernur, “América Latina: Los espacios del ‘otro’,” in *A fin de siglo. Cien años de arquitectura* (Los Ángeles/México: MOCA/Antiguo Colegio de San Ildefonso, 1998), 277-315.
6. Gui Bonsiepe, *A tecnologia da tecnologia [el diseño de la periferia]* (São Paulo: Edgard Blücher, 1983).
7. Walter Mignolo, “Introduction: Coloniality of power and de-colonial thinking,” *Cultural Studies* 21, no. 2-3, (2007): 155-167, <https://doi.org/10.1080/09502380601162498>
8. Walter Mignolo and Rolando Vazquez. “The Decolonial AestheSis Dossier,” *SocialText Online* (2013), https://socialtextjournal.org/periscope_article/the-decolonial-aestheSis-dossier/
9. Dalida Benfield, “Decolonizing the digital/digital decolonization,” *Worlds & Knowledges Otherwise* 3, no.1 (2009), <https://globalstudies.trinity.duke.edu/projects/wko-digital-3>
10. Boaventura de Sousa Santos, *Epistemologies of the South: Justice Against Epistemicide*. (London: Routledge, 2014).
11. *Global South Studies*, <https://globalsouthstudies.as.virginia.edu/>

In technological and economic terms, there are conditions in the region defining a context of hybridity: 1) between a structure of late and incomplete industrialization¹² and the introduction of logics from the third and fourth digital revolutions, 2) between the imported models of technology and the development of social technologies,¹³ 3) between cultural traditions related to crafts and the informal economy, and the emergence of the “maker culture” and the new entrepreneurship discourse.¹⁴

In this sense, recognizing “Other Computations” triggers other lines of thought about knowledge and the appropriation actions in Latin America, from the architectural, cultural, and technological fields. In search of otherness, this article aims to outline the recent dynamics of digital fabrication in Latin America, investigating the laboratories that are exploring the use of these technologies in experiments in architecture and object design linked to their own contexts and problems. In short, we are interested in capturing “other digital fabrications” emerging in our own environment.

From Computation to (Other) Computations

Despite the fact it can be affirmed that “contemporary debates about the role of digital technologies in architectural practice and pedagogy tend to be framed in theoretical developments from global knowledge and economy centers”,¹⁵ the culture of inequalities and differences defined by

Canclini can be identified as an important reference to “Other Computations” in Latin America since its beginning. The context of its evolution is different and “other” in a similar way although it tries to legitimize itself from abroad.¹⁷

Marina Waisman¹⁸ argued that, in general terms, for “Europeans and Americans the path to high technology has been one of the sustained evolutions so that its adoption was the logical way to answer to their own circumstances.” Concerning the digital fabrication scenario in the USA and some European universities, digital fabrication laboratories have been installed with advanced technologies due to the connection with industries that manufacture machines (robots, industrial 3D printers, and milling machines) and partnerships with industries, which provide materials for research and experiments. In these regions, technology was promoted in the beginning from the practice of architecture instead of academia:^{19,20} the industry entered into dialogue with academia to achieve common goals.

In contrast, in Latin America, academia turned itself in the principal focus of experimentation on computational design and digital fabrication, where educational practices disseminated novel technologies,²¹ and computational experiments tried to bring answers to technological curiosities.²² An important part of this process emerged in the second half of the first decade of the 21st century: the return of doctoral and master’s

12. Eduardo Gonçalves, Mauro Borges and João de Negri, “Condicionantes de la innovación tecnológica en Argentina y Brasil” *Revista de la CEPAL* 94, (2008): 75-99, <https://repositorio.cepal.org/handle/11362/11244>
13. Renato Dagnino, *Tecnologia Social: contribuições conceituais e metodológicas* (Campina Grande: EDUEPB, 2014).
14. Jacob Carlos Lima, “Participação, empreendedorismo e autogestão: uma nova cultura do trabalho?”, *Sociologias*, 12, no. 25, (2010): 158-198, <https://doi.org/10.1590/S1517-45222010000300007>
15. “Other Computations. Technologies of Architecture and Design in the Global South,” Call for papers Dearq 5, accesses January 15, 2019, https://revistas.uniandes.edu.co/pb-assets/Call-For-Papers/Dearq/5/OtrasComputaciones_ing-1544629513667.pdf.
16. Néstor Canclini, *Desiguales, Desconectados. Mapas de la Interculturalidad* (Barcelona: Gedisa, 2004)
17. An approach to the socio-economic impact of digital fabrication taking several examples from countries in the region including Brazil, Mexico and Peru can be seen in Neil Gershenfeld, Alan Gershenfeld and Joel Cutcher-Gershenfeld, *Designing reality: how to survive and thrive in the third digital revolution* (New York: Basic Books, 2017).
18. Waisman, op. cit., 71 (translation by the authors)
19. Neil Leach and Philip Yuan, *Scripting the Future* (Shanghai: Tongji University, 2012), 1.
20. Neil Leach and Philip Yuan, *Computational Design* (Shanghai: Tongji University, 2018), 13.
21. Maria Betancourt et al., “Open educational practices and technology appropriation: the case of the Regional Open Latin American Community for Social and Educational Research (CLARISE).” *RUSC Universities and Knowledge Society Journal* 11, no. 1 (2014): 4-17.
22. Pablo C. Herrera, “Reutilizando códigos en arquitectura como mecanismos de información y conocimiento: De la programación Escrita a la Visual,” in *Didáctica proyectual y entornos postdigitales. Prácticas y reflexiones en escuelas latinoamericanas de Arquitectura y Diseño*, eds. Diana Rodríguez, María Tosello, and David M. Sperling. (Mar del Plata: Universidad Mar del Plata, 2013), 244.

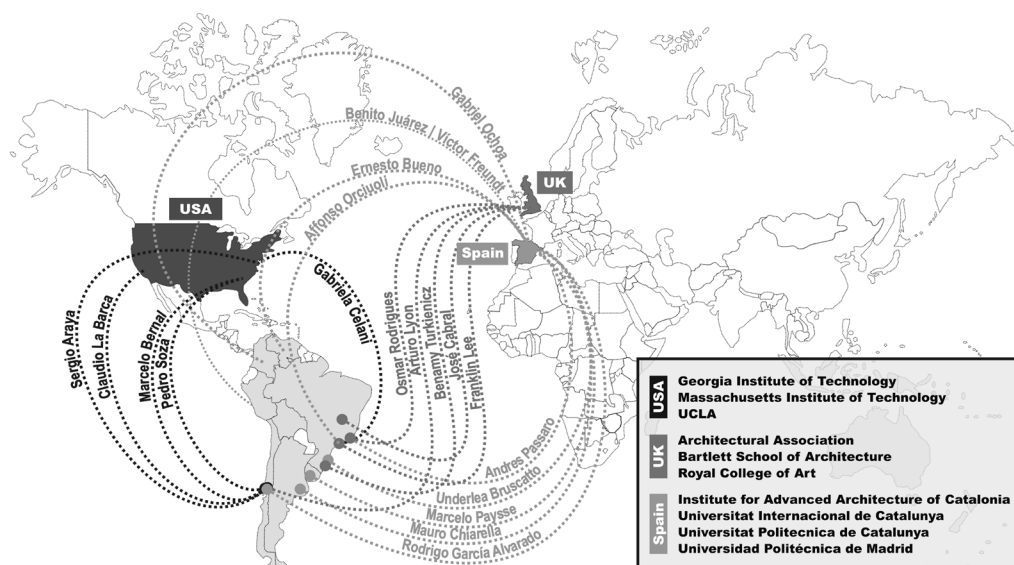


Image 1. Examples of Latin American technological exchanges at the beginning of the 21st century. Source: Based on Sperling; Herrera and Scheeren, 2015.

students in computation design from the northern hemisphere to their countries of origin (Image 1). This technological expertise was mixed with knowledge developed locally in universities that, until then, had almost never been implemented in the area, which led to the emergence of local appropriations in less than a decade. This is a dynamic that has already been previously discussed as migratory movements.²³

A second period was characterized by exchanges between the first generation and their postgraduate students, who became professors and implemented new laboratories, or started to work in architecture offices. In a previous study, we have already pointed out these dynamics, involving the occurrence of regional nucleation²⁴ and their insertion into larger economic, cultural, and academic processes.

This context of migration movements and regional nucleation dialogues with what Canclini sta-

ted about migrations, differences, and interculturalities: those who migrated to new horizons “changed their ways of belonging, identifying and facing oppression or adversity.” These appropriations encouraged a particular mode of computation in the context of digital fabrication that is systematically shown in this research’s analysis.

Mapping Computations and Digital Fabrication in Latin America

According to Mumford,²⁶ we should not explain the existence of the new instruments—in his case, the mechanical ones—but the culture that was willing to use them, and then we should extensively explain their use. A complementary approach about the need to comprehend technological scenarios that is in line with the cultural contexts and exchanges can be found in Lemon & Medina; it looks to “how scholarship on Latin America can enrich investigations of technology and how the history of technology can broaden studies of Latin America history”.²⁷

23. David M. Sperling, Pablo C. Herrera, and Rodrigo Scheeren, “Migratory Movements of Homo Faber: Mapping Fab Labs in Latin America,” in *Computer-Aided Architectural Design Futures. The Next City - New Technologies and the Future of the Built Environment*, eds Gabriela Celani, David M. Sperling, and Juarez M. S. Franco (Berlin: Springer, 2015), 405-421.

24. David M. Sperling, Pablo C. Herrera, Gabriela Celani, and Rodrigo Scheeren, “Fabricação Digital na América do Sul: um Mapeamento de Linhas de Ação a partir da Arquitetura e Urbanismo,” in *Anais do XIX Congresso da Sociedade Ibero-americana de Gráfica Digital*. (Florianópolis: Universidade Federal de Santa Catarina 2015), 119-125.

25. Canclini, op. cit., 53

26. Lewis Mumford, *Técnica y Civilización* (Madrid: Alianza Editorial, 1998), 22

27. Michael Lemon and Eden Medina, “A Review of History of Technology Scholarship on Latin America,” in *Beyond Imported Magic. Essays on Science, Technology, and Society in Latin America*, eds. Eden Medina, Ivan da Costa Marques, and Christina Holmes (Cambridge, MA: MIT Press, 2014), 125.

In order to comprehend the emerging digital culture in the architectural field in our region, with the overall aim of mapping digital fabrication technology appropriation processes,²⁸ the research project *Homo Faber: Digital Fabrication in Latin America* was started in 2014. The methodology involved included: 1) setting up a database about digital fabrication laboratories in Latin America, 2) sending structured surveys to the laboratories, 3) constant updating of the database, 4) qualitative and quantitative analysis of the collected data, 5) elaboration of maps, diagrams and charts from the data, 6) writing of scientific articles focused on contexts, concepts, and case studies, and 7) organization of triennial exhibitions.

Although there are worldwide follow-ups of the groups associated with Fab Labs^{29,30} or Makerspaces,³¹ the specificity of digital fabrication laboratories in the region has not been investigated from a manufacturing, infrastructure, or human resources point of view in Central and South America.³² Also, the current information has not been expanded beyond the laboratories connected to networks including Fab Foundation or Fab Lat. While only 11 of the 52 laboratories mapped in this study are linked to networks, the other 41 are “independent” but sharing their work in

conferences and publications. This research was supplied by the authors’ individual investigations and by advising and mentoring master’s and doctoral postgraduate research on the following topics including: computational design, visual and textual programming, fab labs, digital crafts, theories, and design processes.

The first results of the Homo Faber: Digital Fabrication in Latin America Project showed initiatives from South America at the exhibition held as part of the CAAD Futures 2015 “The Next City” Conference, in São Paulo, Brazil. The authors presented “a recent context of starting and development of fab labs in Latin America. Beginning in university research centers, and consolidated in university platforms, this movement expands with the formation of laboratory networks and the emergence of studios and independent researchers investigating and exploring new uses for digital fabrication in architecture and in related fields.”³³

The texts “Form and Material”, “About Forms and Formulae”, and “The Factory” were published in the book *The Shape of Things. A Philosophy of Design* (1999)³⁴ by Vilém Flusser. They were used to compose the conceptual basis of the first

28. About the concept of technological appropriation see: Bonsiepe, op. cit.; Jacky A. Swan and Peter Clark, “Organizational Decision-making in the Appropriation of Technological Innovation: Cognitive and Political Dimensions”, *European Work and Organizational Psychologist* 2, no. 2 (1992): 103-127, <https://doi.org/10.1080/09602009208408538> and Antti Salovaara and Sakari Tamminen. “Acceptance or Appropriation? A Design-Oriented Critique of Technology Acceptance Models,” in *Future Interaction Design II*. (London: Springer, 2009), 157-173, https://doi.org/10.1007/978-1-84800-385-9_8
29. Fab Foundation was created by MIT’s Center for Bits & Atoms FabLab Program in 2009. Map source: <https://www.fablabs.io/labs/map>
30. *Makery* is an open source cartography based on data from the Fab Foundation (which indexes fablabs charted by MIT), hackerspaces.org, diybio.org, and its own research. Map source: <http://www.makery.info/labs-map/>
31. *The Makermap* was created in 2012 as an open source project to create a global database of maker resources (Map source: <http://themakermap.com/>). Make Community also maintains an updated Makerspace map from its home page (<https://makerspaces.make.co/>)
32. Representative cases of Latin American computational explorations relating to design, architecture, and digital issues have not been seen in many exhibitions previous to the 21st century. Between 2000 and 2009, the Far Eastern International Digital Design Award (FEIDAD), curated by Yu Tung-Liu, selected design proposals from Latin American master’s students. These exhibitions were followed by the Architecture Biennial Beijing (ABB) between 2004 and 2010, curated by Leach and Wei-Guo. Latin America had a section under the curatorship of the Chilean Matias del Campo, who exhibited works about computational explorations in 2008 (Neil Leach and Xu Weiguo, *Architecture Biennial Beijing: (Im)material Processes. New Digital Techniques for Architecture*. Beijing: Tsinghua University, 2008, 194-219) and digital fabrication in 2010 (Neil Leach and Xu Weiguo, *Architecture Biennial Beijing: Machinic Processes*. Beijing: Tsinghua University, 2010, 194-225). In 2012, exhibitions referring to the global South included Asian and Australian initiatives (Neil Leach and Philip Yuan, *Fabricating the Future*. Shanghai: Tongji University Press, 2012) but Latin America did not participate until these local exhibitions: Homo Faber: Digital Fabrication in Latin America (2015), Homo Faber 2.0: Politics of Digital in Latin America (2018), and Digital Craft in Semi-peripheral Nations (Pablo Iriarte. “Digital Craft in Semi-peripheral Nations,” in *Projects Catalog of the 38th ACADIA 2018*, 2018, 50-72, in Mexico City (ACADIA 2018). They collected more than a hundred experiences with computational appropriations from different realities, marking a different situation from the foreign computational dependence that South America experienced during the first decade of the 21st century.
33. David M. Sperling and Pablo C. Herrera eds. *Homo Faber: Digital Fabrication in Latin America CAAD Futures 2015> The Next City*. 1. ed. (São Carlos: Instituto de Arquitetura e Urbanismo, 2015), 7.

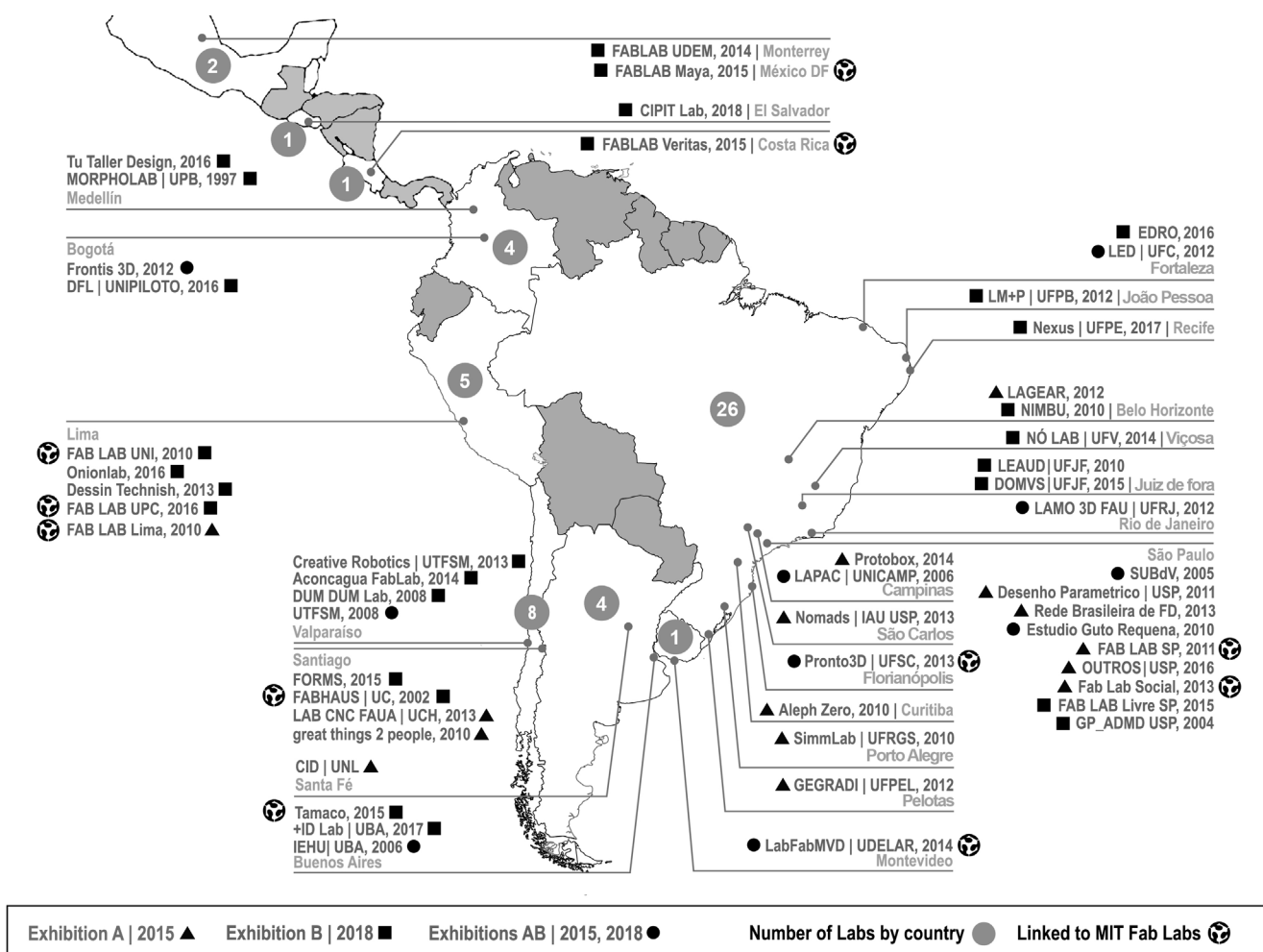


Image 2. Laboratories in Homo Faber 1.0 (2015) and Homo Faber 2.0 (2018). Source: Authors.

exhibition. Using these, “by understanding the digital fabrication as a process that takes both two-way, ‘informing materials’ and ‘materializing forms’, we tried to articulate common aspects of the works presented, based on four informing lines: surfaces, objects, spaces and social processes.”³⁵

The second edition of the exhibition, Homo Faber 2.0: Politics of Digital in Latin America, was held as part of the XXII SIGraDi Conference “Technopolitics” 2018, in São Carlos, Brazil. Including Central and South America, its objective was “to

be bound to politics and society, showing the potential of digital fabrication and its impact on communities, evidencing how the identity of the projects evolves the constant experimentation of form and material for the development of new products or the improvement of existing ones, from the object to the architectural scale.”³⁶

Discussions from ideas developed in texts including “Do Artifacts Have Politics?”³⁷ “Arquitectura y política. Ensayos para mundos alternativos”³⁸ and “Politics and Digital Fabrication. An ongoing debate”³⁹, directed the theoretical framework

34. Originally published in German in 1993.

35. David M. Sperling and Pablo C. Herrera, *op. cit.*, p.10.

36. Rodrigo Scheeren, Pablo C. Herrera, and David M. Sperling, eds., *Homo Faber 2.0: politics of digital in Latin America*. (São Carlos: IAU/USP, 2018), 11.

37. Langdon Winner. “Do Artifacts have Politics?,” *Daedalus*, 109, no. 1, (1980): 121-136, <https://www.jstor.org/stable/20024652>

38. Josep Maria Montaner and Xaida Muxí, *Arquitectura y política. Ensayos para mundos alternativos* (Barcelona: Editorial Gustavo Gili, 2011)

39. Nuria Álvarez and Francisco González de Canales, *Arquitectura y política. Ensayos para mundos alternativos* (Sevilla: vibok works, 2017).

of the second exhibition and its organization in sections as follows: Collaborative Processes & Technological Subversions (CP&TS); Conceptual Prototypes & Technological Products (CP&TP), and Artisanal Digital & Cultural Artifacts (AD&CA).

Image 2 shows the laboratories displayed on Homo Faber 1.0 (2015) and Homo Faber 2.0 (2018) according to their location, and Table 1 shows them in relation to the categories used in each exhibition.

Recent Data from the Latin American Digital Fabrication Scene

Comparative data analysis between the two selections and their evolution in the triennium is relevant to help understand the Latin American scene (Table 2). In this study, the laboratories were classified according to their profile, Teaching, Research, and Extension (TRE) and Architectural Design Studios (ADS). Their focuses were subdivided in categories: Experimental Research (EXR), Application of Technology in Construction (ATC), and Social Technology (SOT).⁴⁰ Each one of these categories was further subdivided to emphasize: Process (PCS) or Product (PDT). Additionally, the manufacturing application scales were defined as Object Scale (OS) and Architectural Scale (AS).

Experimental Research is considered to be oriented to the development of processes or objects, at an experimental level, still without immediate application in the productive sector. Application of Technology in Construction is understood as the development of processes or products that are already at an application stage in construction. Social Technology is understood as technologies developed with or for communities meeting social demands.

The existence of technological appropriation was identified according to local constraints (FL = From the Local) and global references (FG = From the Global). In this aspect, the incorporation of

cultural references and the articulation with elements of the constructive traditions of the region were considered.

Comparative analysis between the general data of 2015 and 2018 indicate that: 1) Experimental Research remains the main focus, followed by Technology Application in Construction and Social Technology; 2) Social Technology presented a small growth between the two samples; 3) there was an increase in the number of laboratories working in Architectural Scale; 4) there was an increase in the technological appropriation from local conditions.

The cross-references between profiles, focus, emphases and scales from 2015 and 2018 show other significant correlations: 1) Teaching, Research, and Extension laboratories are mainly oriented to Experimental Research (emphasis on Process and Product), and then to the development of Social Technologies, 2) Architectural Design Studios are mostly oriented to the Product emphasis on Technology Application in Construction, without applications in Social Technology, 3) technological appropriation in dialogue with local cultural identities is significantly more present in the Teaching, Research and Extension laboratories than in the Architectural Design Studios, 4) Teaching, Research, and Extension laboratories and Architectural Design Studios that participated in the two surveys kept the focus of their production, oscillating between the emphasis on the process or the product, 5) there was a growth of Architectural Scale jobs developed by Architectural Design Studios.

Local Appropriations in Latin American Digital Fabrication Laboratories

From the categorizations shown in Table 2, it was possible to identify that 32 laboratories from a total of 52 are working on local appropriations and reinterpretations in the context of "Other Computations"; they are rewriting the

40. It is known that, in general, the activities of a digital fabrication laboratories are varied and can change over time according to internal and external conditions and demands. Therefore, to define the focus of the activities of the laboratories, the works sent to the exhibitions were taken as objects of analysis, which are indicative of what the laboratories themselves identify to be the best example of their production.

41. "Other Computations. Technologies of Architecture and Design in the Global South," op. cit.

history of computer technology in the region. After analyzing similarities in their work, we classified them into six groups: Bottom-Up; Community / Digital craft in communities; Components; Mobile FabLab; Low-High Technologies; and Hacking. In keeping with this Dearq call-for-papers, these six groups are promoting "histories, theories, or projects across the architectural, artistic, and pedagogical"⁴¹ in their countries. Driven by academic networks, the work of these laboratories is increasing in relevance and visibility. Table 3 shows the intersection of the 52 laboratories with these six groups that have case studies in nine countries in the region. Image 3 shows examples of local appropriations in Latin American Digital Fabrication Laboratories.

Bottom-Up: proposals that are somehow linked to the industry, but working on alternative technological solutions promoting Top-Down implementation processes. New ways of exploring industrial equipment and materials, as well as the use of machines that the local industry does not have, are promoting the integration of emerging technologies with automated processes. The component or module ceases to be a unique prototype: assemblies and joints are studied based on local techniques that reach the architectural scale. Protobox (Brazil), UTFSM (Chile), and Dessin Technish (Peru) are examples of this group.

Community / Digital craft in communities: initiatives that identified particular needs in each community, and some potentialities of including individuals or groups in the processes (from the periphery to academia). This includes working with artisans and local groups that promote improvements or variability in traditional proposals:⁴² FABLAB Livre SP (Brazil), FABLAB Maya (Mexico), and FABLAB Lima (Peru). These are not welfare practices, but participatory projects that integrate local processes with public policies and academics in a synergy of mutual benefit.

Components: investigations or products focused on parts of a project or building and include the CNC production of flat panels or joints on an architectural scale. Examples are LAPAC (Bra-

zil), Frontis3D (Colombia) and its façade modules, UDEM (Mexico) and the exploration of wood ceilings, and FORMS (Chile) and the development of a set of modules reaching a height of 10 to 20m creating a fog barrier to optimize the capture of rainwater on the coast.

Mobile FabLab: initiatives that created mobile infrastructures to move to peripheral communities and small cities. Most of them work in collaboration with other institutions and public policies, in order to promote social transformation and technological inclusion. This is the case of FABLAB Veritas (Costa Rica), Pronto3D (Brazil), Aconcagua FabLab (Chile), and FabLab Maya (Mexico).

Low-High Technologies: experimentations that perform reinterpretations of local construction processes (metal, wood, concrete) using diverse digital fabrication technologies. SUBdV (Brazil) is the emblematic case in this group, which drives a "tropicalized" digital aesthetic. NEXUS (Brazil) explores the malleability of coconut fiber to create the Leaf Brick and boosts the regional economy and drives different aspects of sustainability. Along the same lines, the brick architecture of the Uruguayan Eladio Dieste is reinterpreted by the LabFabMVD (Uruguay) by using plywood boards to achieve the same double curvature shape.

Hacking: experiments investigating the error in manufacturing objects by 3D printing machines. They are exploring the failures of the standards, altering or demystifying the perfection of technology. Dysgraphia from gt2p (Chile) is the result of a "programmed error" that exposes some weakness of the systems. Moreover, "3D error" from Outros (Brazil) is a collection of 100 pieces that exhibit waste and failures unintentionally produced in 3D printing machines.

These six local appropriation groups (Bottom-Up, Community / Digital craft in communities, Components, Mobile FabLab, Low-High Technologies, and Hacking) are recognized by this investigation as being the leading Latin American digital fabrication laboratories that are developing a deep connection with local realities, picking up demands, and then working with them to find new

42. Walter Gonzalez Arnao, *Neo-Handicraft in America. Methods to incorporate digital fabrication processes into handicrafts* (Lima: Universidad Nacional de Ingeniería, 2019).

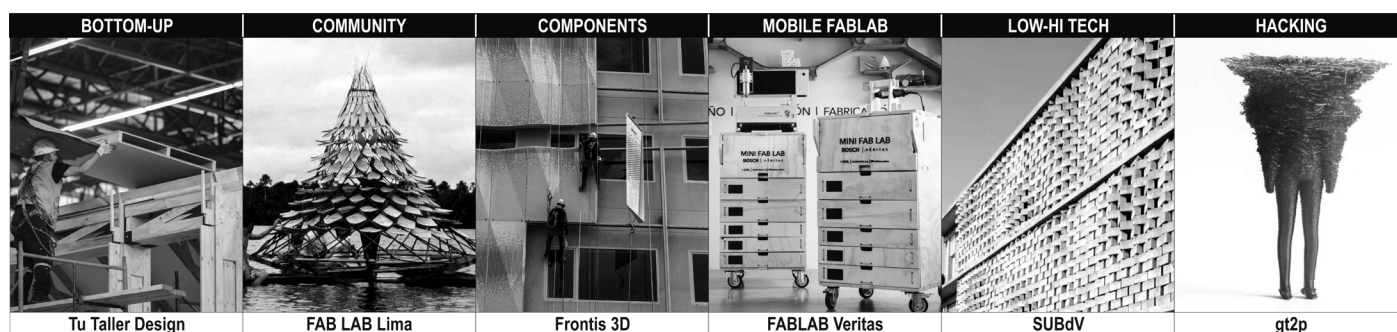


Image 3. Examples of local appropriations in Latin American Digital Fabrication Laboratories. Source: Authors.

solutions and other lines of questioning. The pertinent question here is the synthesis these groups are making between advanced technologies of fabrication and local common situations. Instead of replicating experiments from abroad, they are applying new technologies to solve real problems, indicating ways of acting inside both socio-economic and cultural situated realities as co-participants in collaborative processes. Nowadays, they can be seen as creative findings to face and to consider the Latin American context of hybridity we pointed out at the beginning of this text.

Conclusions: Actions Between the Local and the Systemic

Transformations in Latin American architecture and design that have arisen since the introduction of computing and the most recent introduction of digital fabrication, are currently characterized by different gradients in teaching, research, and the construction industry. In teaching, while the introduction of software is widespread due to the information available in the networks, the opening to other design procedures and formal proposals still occurs in a particular and gradual way, more by professors' initiatives than from systemic changes in teaching programs.

These initiatives have been clearly started from investigations carried out by academics. While there are still only several actions in each locality, these proposals have established some level of network and knowledge exchange through conferences such as SIGraDi and the sister societies from other continents. Technology transfer and technology appropriation centers have been established by these actors as laboratories oriented towards Teaching, Research, and Extension. Their

path is composed of one or more of the following aspects: 1) previous experience on training abroad, 2) insertion of CAAD and digital fabrication in undergraduate courses, 3) coordination of postgraduate studies, 4) providing updated courses for architects, 4) regional nucleation of other research centers, 5) dissemination of research in congresses and publications, 6) induction, from actions 2 to 5, to the creation of new digital Architectural Design Studios.

The performance of the Architectural Design Studios is more directly linked to the development of products for the construction industry or the artistic field. In general, they are developing research with less short-term applications in the construction sector and having more dialogue with local cultural identities.

The Teaching, Research and Extension initiatives of Social Technology development are significant, but still incipient, considering the Latin American context of hybridity pointed out at the beginning of this article. One of the differences highlighted by "Other Computations" in this topic is that, unlike in the northern hemisphere that has social initiatives supported by welfare programs, the implementation of technologies, and funding programs, the southern hemisphere turns to hybrid manual and digital craft processes. These in-process experiments are being made on the scale of the object in Argentina, Brazil, Colombia, Mexico, Peru, and Uruguay.

Furthermore, there are technology parks capable of dealing with digital fabrication in several Latin American cities. However, the technological transfer and appropriation of digital architectural design and digital fabrication by the construction

sector is still a challenging factor in the face of super-structural conditions such as: low investment in design innovation, production chains based on the assembly of serial products, and availability of low-cost manpower. At this point, "Other Computations" is clarified with the integration of Low-Tech and High-Tech that is being used by some of the laboratories. This is an important assessment of synergy since, instead of trying to change the system by top-down actions, they are proposing new bottom-up processes, again by exploring the hybridity condition.⁴³

Although it seems that this process should be systemic or its results should follow articulated actions to encourage innovation, the initiatives selected by the Homo Faber: Digital Fabrication in Latin America Project shows that there is a significant appropriation of local identities enhanced by computer technologies and digital fabrication in the region. This fosters the adaptability of widespread control techniques into projects focusing on solving small local problems and establishing knowledge to face the challenges of scarcity technological accessibility. In this scenario, some postgraduate programs located mainly in Argentina, Brazil, and Chile are playing a decisive role. They still do not represent a considerable percentage of the programs in the region; however, they are, in our view, the faithful reflection of "Other Computations", which inspire new paths for their systematic implementation.

Looking at the examples selected by this investigation, the historical positions of dependence or resistance cannot explain their production conditions and what they are producing. They should be understood as re-existences: in other words, as the creation of new syntheses between cultural and technological processes in the Latin American context.



References

1. Betancourt, María, Rosario Celaya, and María Ramírez. "Open educational practices and technology appropriation: the case of the Regional Open Latin American Community for Social and Educational Research (CLARISE)". *RUSC Universities and Knowledge Society Journal* 11, no. 1 (2014): 4-17.
2. Benfield, Dalida. "Decolonizing the digital/digital decolonization", *Worlds & Knowledges Otherwise* 3, no.1 (2009), <https://globalstudies.trinity.duke.edu/projects/wko-digital-3>
3. Bonsiepe, Gui. *A tecnologia da tecnologia [el diseño de la periferia]*. São Paulo: Edgard Blücher, 1983 [1985].
4. Canclini, Néstor. *Diferentes, Desiguales, Desconectados*. Mapas de la Interculturalidad. Barcelona: Gedisa, 2004.
5. Dagnino, Renato. *Tecnologia Social: contribuições conceituais e metodológicas*. Campina Grande: EDUEPB, 2014.
6. Fernández Cox, Cristian. "Modernidad Apropiada, Modernidad Revisada y Modernidad Reencantada", in *Modernidad y Postmodernidad en América Latina*. Bogotá: Escala, 1991.
7. Flusser, Vilém. *The Shape of Things: A Philosophy of Design*. New York: Reaktion Books, 1999.
8. Frampton, Kenneth, "Towards a Critical Regionalism: Six Points for an Architecture of Resistance" in *The Anti-Aesthetic. Essays on Postmodern Culture*. Seattle: Bay Press, 1983.
9. Gershenfeld, Neil, Alan Gershenfeld, and Joel Cutcher-Gershenfeld. *Designing reality: how to survive and thrive in the third digital revolution*. New York: Basic Books, 2017.
10. Gonçalves, Eduardo, Mauro Borges, and João de Negri. "Condicionantes de la innovación tecnológica en Argentina y Brasil". *Revista de la CEPAL* 94 (2008): 75-99.
11. González, Francisco, and Nuria Álvarez. *Politics and Digital Fabrication. An Ongoing Debate*. Sevilla: Vivok Works, 2017.
12. Gonzalez Arnao, Walter. *Neo-Handicraft in America. Methods to incorporate digital fabrication processes into handicrafts*. Lima: Universidad Nacional de Ingeniería, 2019.

43. Elza Miyasaka, Tassia Borges Vasconcelos, Rodrigo Scheeren et al., "Hybrid cultures: design and construction strategies of complex shapes in Brazil in the first digital age", in: *Frontiers of Science and Technology. Automation, Sustainability, Digital Fabrication*, ed.(s) Gabriela Celani and Olfa Kanoun. (Berlin: Walter de Gruyter, 2017) 125-138, <https://doi.org/10.1515/9783110537680-009>

13. Gutiérrez, Ramón. *Arquitetura Latino-americana: textos para reflexão e polémica*. São Paulo: Nobel, 1989.
14. Herrera, Pablo C. "Reutilizando códigos en arquitectura como mecanismos de información y conocimiento: De la programación Escrita a la Visual," in *Didáctica proyectual y entornos post digitales. Prácticas y reflexiones en escuelas latinoamericanas de Arquitectura y Diseño*, eds. Diana Rodríguez, María Tosello, and David M. Sperling. Mar del Plata: Universidad Mar del Plata, 2013: 238-254.
15. Iriarte, Pablo. "Digital Craft in Semi-peripheral Nations," in *Projects Catalog of the 38th ACADIA 2018*, 50-72.
16. Leach, Neil, and Philip Yuan. *Scripting the Future*. Shanghai: Tongji University, 2012.
17. Leach, Neil, and Philip Yuan. *Fabricating the Future*. Shanghai: Tongji University Press, 2012.
18. Leach, Neil, and Philip Yuan. *Computational Design*. Shanghai: Tongji University, 2018.
19. Leach, Neil, and Xu Weiguo. *Architecture Biennial Beijing: (Im)material Processes. New Digital Techniques for Architecture*. Beijing: Tsinghua University, 2008.
20. Leach, Neil, and Weiguo, Xu. *Architecture Biennial Beijing: Machinic Processes*. Beijing: Tsinghua University, 2010.
21. Lemon, Michael, and Eden Medina. "A Review of History of Technology Scholarship on Latin America," in *Beyond Imported Magic. Essays on Science, Technology, and Society in Latin America*, edited by Eden Medina, Ivan da Costa Marques, and Christina Holmes. Cambridge, MA: MIT Press, 2014.
22. Liernur, Jorge Francisco. "América Latina: Los espacios del 'otro'" in *A fin de siglo. Cien años de arquitectura*. Los Ángeles/México: MOCA/Antiguo Colegio de San Ildefonso, 1998.
23. Lima, Jacob Carlos. "Participação, empreendedorismo e autogestão: uma nova cultura do trabalho?." *Sociologias*, 12, no. 25, (2010): 158-198, <https://doi.org/10.1590/S1517-45222010000300007>
24. Mignolo, Walter. "Introduction: Coloniality of power and de-colonial thinking", *Cultural Studies* 21, no. 2-3, (2007): 155-167, <https://doi.org/10.1080/09502380601162498>
25. Mignolo, Walter, and Rolando Vazquez. "The Decolonial AestheSis Dossier," *Social Text Online* (2013), https://socialtextjournal.org/periscope_article/the-decolonial-aestheSis-dossier/
26. Miyasaka, Elza, Tassia Borges Vasconcelos, and Rodrigo Scheeren. "Hybrid cultures: design and construction strategies of complex shapes in Brazil in the first digital age," in: *Automation, Sustainability, Digital Fabrication*, edited by Gabriela Celani and Olfa Kanoun, pages. Berlin: Walter de Gruyter GmbH & Co., 2017. <https://doi.org/10.1515/9783110537680-009>
27. Montaner, Josep, and Zaida Muxí. *Arquitectura y Política. Ensayos para mundos alternativos*. Barcelona: Editorial Gustavo Gili, 2011.
28. Mumford, Lewis. *Técnica y Civilización*. Madrid: Alianza Editorial, 1998.
29. Salovaara, Antti, and Sakari Tamminen. "Acceptance or Appropriation? A Design-Oriented Critique of Technology Acceptance Models" in *Future Interaction Design II*. London: Springer, 2009, 157-173, https://doi.org/10.1007/978-1-84800-385-9_8
30. Santos, Boaventura de Sousa. *Epistemologies of the South: Justice Against Epistemicide*. London: Routledge, 2014.
31. Scheeren, Rodrigo, Pablo C Herrera, and David M. Sperling (Editors). *Homo Faber 2.0: Politics of Digital in Latin America*. São Carlos: IAU/USP, 2018.
32. Sperling, David M., Pablo C. Herrera, and Rodrigo Scheeren. "Migratory Movements of Homo Faber: Mapping Fab Labs in Latin America," in *Computer-Aided Architectural Design Futures. The Next City - New Technologies and the Future of the Built Environment*, Edited by Gabriela Celani, David M. Sperling, and Juarez M. S. Franco. Berlin: Springer, 2015: 405-421.
33. Sperling, David M., Pablo C. Herrera, Gabriela Celani, and Rodrigo Scheeren. "Fabricação Digital na América do Sul: um Mapeamento de Linhas de Ação a partir da Arquitetura e Urbanismo," in *Anais do XIX Congresso da Sociedade Ibero-americana de Gráfica Digital*. Florianópolis, 2015: 119-125.
34. Sperling, David M., and Pablo C Herrera (Editors). *Homo faber: Digital Fabrication in Latin America CAAD Futures 2015> The Next City*. São Carlos: Instituto de Arquitetura e Urbanismo, 2015.
35. Swan, Jacky, and Peter Clark. "Organizational Decision-making in the Appropriation of Technological Innovation: Cognitive and Political Dimensions," *European Work and Organizational Psychologist* 2, no. 2 (1992): 103-127, <https://doi.org/10.1080/09602009208408538>
36. Waisman, Marina. *La arquitectura descentrada*. Bogotá: Escala, 1995.
37. Winner, L. (1980). "Do Artifacts have Politics?," *Dædalus, Modern Technology*. Problem or Opportunity, 109 no. 1: 121-136.