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How Housing Digitalization May Change the Ways the Built Environment Is Designed and Built

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This paper was presented as part of "Panel 1: How Is Digitalization Changing How Housing Is Designed & Built?" at the symposium "Bringing Digitalization Home: How Can Technology Address Housing Challenges?", hosted by the Harvard Joint Center for Housing Studies in March 2022 and funded by Qualcomm. Participants examined the changes that digitalization—the use of automated digital technologies to collect, process, analyze, distribute, use, and sell information—is spurring in the way housing is produced, marketed, sold, financed, managed, and lived in.

Abstract

This paper reflects upon the panel “How Is Digitalization Changing the Ways Housing Is Designed and Built?” held at the March 2022 symposium “Bringing Digitalization Home.” This panel was the first and only conversation of the symposium focused specifically on the architectural scale. The discussion revealed that the social, cultural, and disciplinary challenges surrounding digital transformation in housing are hurdles no less significant than the technological ones. Key themes included socio-technical challenges preventing the efficient industrial production of housing, namely the lack of industrial standards; and the socio-technical challenges embedded in the design of housing, namely the emerging creative challenge of human-machine collaboration. Both types of digitalization challenges require a clarified set of values to drive future progress and innovation through both public and private investment. This reflection ultimately concludes that housing digitalization reveals an imperative for structural redefinition within practices of the built environment and a need for public investment in research and development in the face of digital transformation.

Introduction

By convening under the banner of "digitalization," the Joint Center for Housing Studies marked out a transformational ambition for the symposium. The topic itself is an acknowledgement that we are on a path that exceeds the work of converting housing-related information into zeros and ones and automating or innovating upon previously human tasks in the service of more and better housing. This first panel on the design and construction of housing featured the only conversation focused specifically at the architectural scale; the panel revealed that the social, cultural, and disciplinary challenges that arise from—and are precursors to—digital transformation in housing are hurdles that are no less significant than the technological ones.

Our conversation on digitalization in the design and construction of housing was two-sided. On one hand, a practical but complex socio-technical challenge rooted in inadequate industry standards; on the other, a more philosophical challenge in which housing digitalization calls into question the role of design and the public sector in the provision of the built environment. Both reveal housing as a metaphorical "tip of the spear" for the disruption of the structural potentials of practices of the built environment more broadly. This paper is thus broken into two related sections, both of which address the value systems and social and cultural challenges that must be articulated and encountered along the path of digitalization in housing and the urban form it generates. The first section addresses housing digitalization as a design engineering problem; the second section frames housing design as an entry point into a new mode of collaboration and structuring design processes to conceptualize architecture and urban form. Rather than a proposal on how we might technologically accomplish the task of digitalization, this work reflects on the social, cultural, and ethical imperatives we must consider before engaging the technological challenge of digitalization.

To begin, the housing unit is framed as a prescient element of urban form that provides a leading-edge exploration into the implications of scalable and socio-technical systems within the practices of the built environment. Of all architectural types, housing is the most unitized, scalable, and universally needed. Housing units are the smallest and most pervasive building blocks of urban form. They deeply affect the everyday experience of individual citizens, and in aggregate, they shape the contours and character of the public realm. They tend to be self-similar to accommodate the common denominators of living such as toilets, sleeping, and cooking; however, they are also relatively expensive on a price per square foot basis because of the intensive servicing requirements of water and other utilities on a per unit basis. To ensure public safety and the provision of living across many income levels, housing design and

construction are highly regulated and supported by the public sector at the level of project funding (but not funded for systemic innovation).

The housing crisis attracts private capital at both the local level (project-based capital) and at the level of innovation (venture capital, industry investment, etc.) to fill the market gap. The latter is often preoccupied with utilizing financing and product-based solutions, which promise lower relative risk and higher and faster returns in comparison with solutions that contend with the idiosyncratic complications of local context or systems level change. The prescient potential of unit replicability and scalability, along with a market gap rising out of the housing crisis and the critical civic role housing plays in the creation of a just city, make the digitalization of housing design and delivery an imperative both outside and inside practices of the built environment. Because of these external pressures, however, housing is also an architectural type that is highly resistant to innovation through traditional design methods, requiring a shift in design methods and values to ensure relevance and catalyze transformative change from within. Housing digitalization is important as both a general pursuit in society and as a leading-edge indicator of massive change within the production of the build environment more broadly. The conversation is not whether, but how, design and construction will play a role, whether they will collaborate or compete, and how this trend will affect the role of design in housing and society more broadly.

Housing Digitalization Is an Integrated Design-Engineering Problem

The challenge has roots at the systems level, and we must encounter it as a multi-disciplinary socio-technical challenge. The panel conversation catalyzed by the work of Smith, Rupnik, and Schmetterer shines light on the idea that a primary barrier to digitalization lies in the inability of the housing design and construction sector to agree on norms and standards for industrial production,[1] which are precursors to the efficient and scalable delivery of housing units.

It is clear that the challenge of consensus around standards between and across both industry and design practice is a significant impediment to effectively delivering housing units using offsite construction, and that offsite construction holds the promise of highly efficient housing production. The

[1] A note on standards and norms versus codes and regulation: The former provides an agreed-upon mechanism, process, or set of specific directives as to how to produce housing, while regulations often take the form of code and are mandated by governing bodies to ensure public safety and sometimes quality. Private sector industry standards enable manufacturers, engineers, and designers to produce a diverse group of parts that will work together to form a building, while public regulations provide a list of minimum viable attributes that must be provided for human occupation.

panel conversation points toward the possibility that we must address the embedded set of constructs that create silos of information and action by contraposing the part against the whole, and the builder against the designer, in order to address the socio-technical problem of standards and scalability.

These technical and social constructs—ways of understanding the processes of designing and building architectural form—have defined the practice of architecture as distinct from construction since the Renaissance. In order to achieve digitalization in housing, however, the architect must seamlessly bridge the silos of design and construction. One proposed pathway toward integration involves the revival of the master builder, a role inextricably tied to construction and the design of contemporary off-site manufacturing. While leadership that integrates design and construction to streamline coordination, break down silos, and generate standards appears as an obvious solution, the perceived trade-off for the architect is significant, requiring that the designer loosen their status as an artist in order to achieve broader impact in a future society in which digital transformation merges the design and building production processes.

Additionally, we must address the design process itself. This same historical baggage provides us with a view of the design process as a top-down (whole first) conceptualization of a building and the construction process as a bottom-up (voxel and process first) approach. If the goal is seamless knowledge and coordination in the service of quality, we must also address the extent to which the architect must participate in designing the voxels or modules and the standards that allow the voxels to assemble, a role historically relegated to either craft guild or industry. Such a design process would re-situate the role of the architect in society and the structural potentials of practice. It may also open up pathways for communication and break down silos between design and construction to enable standards and a new (or new again) role of the master builder—in which vertical integration may align the pieces in a more integral and standard-driven way—to encounter housing digitalization as a design engineering challenge.

Housing Digitalization Is a Team Sport

From the perspective of digital transformation, the imperative for collaboration is present across multiple fronts. In addition to the industrial design-build collaboration addressed above, creative collaboration with both human and non-human stakeholders in the form of artificial intelligence is inevitable. A renewed understanding of the collaborative role of the public sector in generating the technology required to catalyze deep innovation and transformation within the housing design and

construction sector is also on the table. Both possibilities require that we collectively confront the value systems that drive the disposition and relevance of housing in society.

Current value systems driving housing design and construction generally group into the areas of (1) better quality and more relevant housing, and (2) more, and more cost-efficient, housing. The former is tied to human experience (individual) and civic life (collective), and the latter to housing security (public) and returns on investment (private).

With an acknowledgement that social change and cultural value systems tend to lead and shape technological change and innovation, we must ask ourselves what values should be represented and prioritized within the process of digital transformation. Do we value pure efficiency? Short-term returns for the private sector? Quality of life for our citizens? Or the long-term growth of a renewed economic sector that will drive future stability and innovation? Right now, because of the scale of the challenge (i.e., market opportunity), private sector investment is stepping in to fill gaps with the expectation of rapid financial returns. As a result, investment in housing innovation generates easily consumable market-ready bundles that prioritize the value of rapid financial returns.

What if we imagine housing as fundamental public infrastructure and a technological imperative—as both a necessity for civil society and as potential for massive economic growth based upon innovations in sectoral technology, standards, and systems—that is worthy of public investment in digital transformation? Within a paradigm of public investment in innovation, as articulated by the economist Mariana Mazzucato in *The Entrepreneurial State*, we may value research in housing as we value research in defense, energy, or health. Deep, rather than shallow, innovation would become essential, and the short-term vision of the private market would be insufficient as a platform for research and development as well as for lasting sectoral growth in private firms. Public investment would become critical to accommodate such a value system. Precedents for investment in this level of technological innovation exist in the Defense Advanced Research Projects Agency (DARPA), Advanced Research Projects Agency – Energy (ARPA-E), and the National Institutes of Health (NIH).

What if we shifted the value system to prioritize quality or the experience of the individual as well as life in the public realm, which are shaped by housing as both unit and urban form? The architect has historically prioritized quality and cultural relevance through the mediation of national or international socio-technical systems with local context (consider building codes or material systems) by balancing knowledge and information with sensitivity and intuition. As the socio-technical systems increase in

scale and complexity, this is also a balancing act between quantitative efficiency and safety on one hand, and qualitative experience and local relevance on the other.

In the context of housing digitalization, José Luis García del Castillo y López suggests that prioritizing quality and the creative mediation of system and place will mean innovating on the creative process itself, which is reconfigured to accommodate new forms of collaboration. Instead of a single architect creating a single building form, the architect works within a multi-disciplinary team of designers and engineers who utilize vast amounts of data and collaborate with artificial intelligence. This emerging form of design balances the frictionless potential of quantification required for digitalization with the beautiful complexities of human culture and the necessary inefficiency of creativity in the design of housing. Such a process, which is focused upon interdisciplinary and human-machine creativity at the service of contextual sensitivity and more relevant housing for twenty-first century life, requires not only a shift in social values but also an acceptance that the role of design now resides primarily in the realms of data collection and process creation.

Conclusion

Digital transformation in housing design and construction is a complex, but not insurmountable, socio-technical challenge. The panel conversation reveals the importance of structuring standards and norms and of opening up what a design process can and may be in an era of artificial intelligence and machine-human collaboration. It also clarifies the socio-technical complexities of such change due to long roots in traditional paradigms of design and construction practice. It is difficult to avoid the stark implications for the design and construction of other forms of architecture and urban form, which may be more complicated to systematize but which are unlikely to escape the inevitabilities of digitalization, including replicability, scalability, machine-human collaboration, and new structural potentials for what it means to practice design. It also underscores the serious need for research into housing that is aligned with value systems that are compatible with, but alterative to, private market financial returns.

Housing digitalization provides more than the potential to deliver more and better living accommodations. It is also a tip of the spear in understanding how the role of design in society is changing in response to digital transformation, and how and whether digital transformation in housing is a public good worthy of public investment in technological innovation.