Journal of World Architecture, 2024, Volume 8, Issue 5
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

The "Digital" Approach Impact Today: Modularity in Interior Architecture

Xinyi Tian*

University of College London, London WC1E 6BT, United Kingdom

Corresponding author: Xinyi Tian, tianhrpr@gmail.com

Abstract: Understanding digital technology requires a shift in mindset that takes into account the broader implications of design, social dynamics, environmental factors, and cultural influences. Acknowledging the fact that technology is not confined to the virtual domain but rather has a tangible influence on our daily lives and the surrounding environment, the extensive integration and potential of digital technologies offer a distinctive prospect to fundamentally transform our shared comprehension of architecture. Digital technologies are revolutionizing design practices, manufacturing processes, and our engagement with and understanding of the built environment, by fostering the development of novel models that promote equity and inclusivity. The application of "digital technologies" can function as a methodology for examining and expressing the possible paths of emerging digital technologies. Extrapolate the expected impact of digital technologies on the design, development, and occupancy of the environment to achieve a more sustainable future in the long run. This paper will examine the potential connections and origins of digital technology concerning modularity, as well as the implications of modularity on forthcoming architectural developments in customization.

Keywords: Modularity; Modular architecture; Interior architecture; Customization

Online publication: November 1, 2024

1. Introduction

The integration of digital technologies, including machine learning, artificial intelligence, big data, and manufacturing processes, is progressively gaining prominence within the construction sector. The pervasive integration of digital technology has permeated global society and all facets of human existence, particularly since the advent of the new millennium in the early 2000s [8]. A wide array of products, encompassing video equipment, cameras, computers, mobile phones, televisions, watches, medical devices, laser gauges, electronic kitchen utensils, and air conditioners, have gained widespread usage in daily existence owing to their dependence on digital technology [8]. The primary objective of this relationship was to augment and complement, while simultaneously engaging in a critical analysis of the established viewpoints regarding the societal implications of technology [6]. The incorporation of digital technologies, such as augmented reality, 3D printing, and artificial intelligence, has become a crucial aspect of the architectural design process. Interior architecture is one of the areas of usage [26]. Digital systems have seamlessly assimilated into the fabric of our everyday existence, assuming a pivotal role in facilitating a myriad of functions, including the conveyance of personal sentiments and ideas, as well as the facilitation of transportation.

2. The theory of modularity

2.1. The emergence of the concept of modularity in architecture

Ever since Henry Ford introduced the production line technique to assemble the Ford Model T in 1913, the construction industry has been actively seeking ways to enhance resource utilization by adopting standardized construction methods and components [23]. The architecture resulting from these procedures can be described as modular architecture; the foundation of modular architecture lies in the conceptualization and implementation of systems composed of discrete repetitive components, commonly known as standard units, and these units demonstrate consistency in terms of their dimensions, configuration, and inherent [22]. These entities can form connections with each other, undergo substitution, or undergo addition. From a theoretical standpoint, the adoption of this architectural approach offers clear competitive advantages, despite acknowledging certain negative connotations. The current architectural challenge in the 21st century pertains to the contemporary modular approach, which aims to facilitate individualized customization of residential dwellings, while simultaneously maintaining cost-effectiveness and upholding high standards of quality.

2.2. What is modularity and modularity in architecture?

A formal definition of a module in the technical context of this paper is an independent unit that can be combined with others and easily rearranged, replaced, or interchanged to form different structures or systems. Modularity combines similar elements or components into independent modules. By doing this, the modules can be modified separately, and in this way, a modular system can quickly adapt to changing requirements and new technology.

A modular architecture refers to a structure that consists of multiple modules, which must adhere to compatible and consistent behaviors and boundary conditions to be integrated. It includes at least two modular functions and two interfaces, which can be either input/output or bidirectional. The size and complexity of the architecture can vary, as the boundaries of the modules are scalable. The merging or joining of modules occurs through interoperable interfaces, which can be unique, selective, or universal. Additionally, functional content can be transferred or shared within the architecture, with the functionality being additive [9]. It is important to note that the potential to form modular entities exists before the actual formation of the modules.

2.3. Why modularity?

Modular systems are easily modified to address future needs. Modularity is the engineering equivalent of a financial option: pay a premium today to exercise an option in the future. Modularity offers different levels of options for the end user to respond to new requirements [3]. Modular designs offer advantageous system design elements that are economically appealing and contribute to the improvement of product support and reliability. Modular designs have the potential to yield cost savings. The subsequent enumeration outlines the anticipated advantages of modularity, contingent upon its successful implementation: The achievement of efficient and uncomplicated integration facilitated by interfaces designed for ease of use. Efficient and streamlined processes for reconfiguration and integration, aimed at facilitating the prompt incorporation of diverse capabilities. Considering the ease of maintenance and the speed at which problems can be resolved, it is of utmost importance to consider these factors across all levels of maintenance. The goal is to maximize the utilization of spare parts while concurrently minimizing the consumption of resources and the frequency of maintenance required for replacement components [9].

2.4. The example of modularity

Consider the following example of modular systems: a Swiss Army Knife. The example will highlight the fundamental advantages and drawbacks of modularity, as well as provide some real instances of the differences between the modularity of design. The versatile design of the Swiss Army Knife enables its owner to better prepare for whatever the future may bring. Because it has so many different tools, the Swiss Army Knife can be used for a variety of purposes, which is better for the person who ultimately uses it. The Swiss Army Knife is therefore a good example of a fundamental trade-off that must often be made when adopting modular design. This trade-off involves enhanced flexibility in exchange for less-than-ideal performance. Because each tool within the knife can function independently, knife designers must manufacture each component individually, tailoring the design of each tool to the volume constraints of the knife chassis. This approach exemplifies modularity in the design process. During manufacturing, all tools might be manufactured on different assembly lines and then combined into a single device on another assembly line.

3. Modularity in architecture and urban planning

3.1. Relationship between modularity and architecture and urban planning

Because its component elements are inherently related to one another, there are relationships to be found at every level. According to Slife, the concept of technology did not spring fully formed from nowhere, as the author of the essay titled “Sociomateriality of Information Systems and Organizing” makes clear [21]. This is an essential point. A relational ontology, on the other hand, holds that “the social and the material are inherently inseparable” [19]. The concept of technology did not spring fully formed from nowhere, as the author of the essay titled “Sociomateriality of Information Systems and Organizing” makes clear. This is an essential point [21].

3.2. Modular in customization

Vitruvius defines proportion as “the correspondence between the members of the whole work” and “the correspondence of the whole with a certain part chosen as a criterion” in the first chapter of his Ten Books of Architecture [25]. The concept of modularity, or “customization,” was applied in the early years.

After a period of flagging interest from the 1970s into the 1990s, design interest in housing is again on the rise, particularly in terms of innovative materials and production systems, “green” buildings, and an activist interest in providing for a broader spectrum of people [1]. Recently, “mass customization” or “modular customization” has become a term used to describe housing production, long used by industrial designers, suggesting a production system that has the stability of quantity (mass) and the flexibility of custom design (customization). This systematic approach to housing, which emphasizes the mass production of shelter to accommodate numerous individuals, predominantly emerged during the Industrial Revolution.

During the early 20th century, the artistic movement known as Neue Sachlichkeit, along with other related movements, focused on the establishment of standardized dimensions for minimal housing units, as well as the effective utilization of emerging materials and technologies. Le Corbusier's Maison Dom-Ino was also conceived as a cost-effective and adaptable system for the mass production of housing, employing contemporary materials and production methods.

3.3. Modular in interior design

The challenge of addressing the increasing complexity of technical systems and the growing interplay between technical and societal aspects necessitates the utilization of appropriate engineering design approaches [10]. According to Lindemann *et al.*, as mentioned by Nambisan *et al.,* as the level of complexity in technical systems rises, there is a corresponding increase in both the level of uncertainty and the number of resources needed during the development process. Due to this rationale, numerous projects rely on legacy systems that undergo modifications across generations as they navigate the delicate balance between incorporating novel functionalities and leveraging established components [17]. Modular solutions provide a notable level of flexibility and can be seamlessly incorporated into diverse architectural structures, including residential complexes, rental properties, purpose-built student accommodations, hotels, communal living spaces, office buildings, and educational institutions.

It is imperative to acknowledge that in the context of co-living and student housing, each module represents an autonomous unit that is furnished with its own set of bathroom amenities. The modules possess the capacity to be constructed in advance at a location separate from the final site, encompassing all necessary components, including windows, flooring, walls, electrical outlets, furniture, and window coverings [15]. The measurements exhibit a high level of accuracy, with precision extended to the nearest millimeter. The integration of corridors into module design is a viable and practical choice. Uniform dimensions for every room are not a prerequisite. Certainly, the integration of modules in a specific location can be employed to attain larger and more expansive areas. After the floors and other interior components have been installed, the integration of supplementary modules within the premises results in a final product that is indistinguishable from conventional rooms. As mentioned earlier, it is important to highlight that the achievement of efficiencies was based on the modular concept of an overarching "end goal," regardless of the size of each specific space or room.

3.4. Modular in urbanism

The modular urban is to increase the quality of community life while reducing housing costs and environmental impact. The strategy for its implementation is detailed below. An accommodating environment fulfills personal needs, adapts to the cadence of everyday life, and provides access to the community and relationships the residents want. To achieve this goal, modular urban seeks to unleash the many advantages of living in compact communities by providing choice and encouraging a feeling of belonging. Humans possess an intrinsic need for interpersonal connection, a modularity strategy entitled for creating multigenerational shared-living spaces in urban cores. People may have both their own space and the benefits of living in a close-knit community thanks to this innovative approach to housing.

"No one size fits everyone." For this reason, rather than conventional single-family houses, we advocate for a variety of apartment buildings. Everyone from a single person to a family of four, from retirees to a group of students, has choices. Staying in the same neighborhood even if you need a new place to live means you can easily trade flats with others in a similar situation.

4. Conclusion

The process of digitization has been characterized as a transformative shift in human behavior and perception. The discipline of architecture and urban is influenced by the progressions in digital technologies, as well as the evolving demands of society. The rise of this phenomenon can be ascribed to the successful incorporation of digital technologies within the domain of intelligent architectural structures, as supported by scholarly investigations and real-world implementations.

The emergence of advanced technologies has enabled individuals to engage in the public sphere within the digital media realm, particularly through the utilization of cyberspace, thereby bypassing the limitations imposed by physical space. The utilization of digital technologies in the realm of space has been acknowledged as an increasingly urgent necessity. The notion of digital development encompasses various dimensions, including economic prosperity, adequate standards of living, convenience in daily life, and spatial needs for habitation. The objective is to improve the user experience through the promotion of comfort, convenience, safety, and the facilitation of work and leisure activities.

Disclosure statement

The author declares no conflict of interest.

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