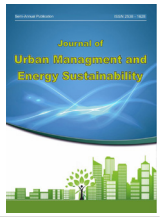
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Reframing Industrial Architecture for Industry 5.0: Architectural Design Requirements from a Generation Z Perspective

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ABSTRACT

The transition from Industry 4.0 to Industry 5.0 requires industrial architecture to move beyond technological infrastructure toward human-centered, sustainable, resilient, and adaptable production environments. However, limited empirical research has translated Industry 5.0 principles and Generation Z-related values into measurable architectural requirements. This study identifies and validates architectural requirements for Industry 5.0 production facilities. A sequential exploratory mixed-methods design was employed. Architectural requirements were identified through literature review and qualitative analysis of open-ended responses and interviews, then evaluated through a cross-sectional survey of 307 employees in an automotive production environment. Exploratory factor analysis reduced the initial 70-item structure to 62 items and identified nine dimensions: Performance Outcomes, Attachment & Retention, Functional Fit, Flexibility & Adaptability, Collaboration & Social, Technology Integration, Autonomy & Control, Physical & Environmental, and Human-Centered & Wellbeing. The re-specified measurement model demonstrated acceptable reliability and fit (KMO = 0.886; Cronbach's α = 0.92–0.94; RMSEA = 0.048; CFI/IFI = 0.93). The findings indicate that industrial architecture should address not only functional efficiency but also spatial participation and justice, environmental quality and safety, flexibility, collaboration, technology integration, autonomy, and human well-being. These priorities can be translated into modular and scalable production spaces, adaptable layouts, accessible welfare facilities, collaborative and learning spaces, clear wayfinding, and responsive environmental-control systems. The study demonstrates how architecture can operationalize Industry 5.0 principles by integrating production performance with workers' physical, social, psychological, and technological needs. Future research should validate the proposed structure using larger independent samples, direct generational comparisons, and diverse industrial and geographical contexts.

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INTRODUCTION

Industrial transformations since the late eighteenth century have consistently been accompanied by changes in production methods, work organization, and the spatial structure of industrial environments. The first Industrial Revolution, rooted in the 1780s, emerged through the utilization of mechanical power derived from water, steam, and fossil fuels, laying the foundations of mechanized production. During the second Industrial Revolution, the advent of electrical energy and the formation of assembly lines and mass production in the 1870s established a new model of production organization. The third Industrial Revolution in the 1970s, marked by the introduction of electronics and information technology, introduced the concept of automation to industries. Ultimately, the fourth Industrial Revolution, relying on the Internet of Things and cloud computing, created a real-time linkage between the physical and virtual worlds through cyber–physical systems (Nahavandi, 2019). Although these transformations have continuously increased productivity and production efficiency, they have gradually generated a gap between technological advancement and the human and social dimensions of production. In response to this rupture, the concept of Industry 5.0 has emerged as a new stage in industrial evolution a stage that views industry not merely as an engine of economic growth, but as a flexible provider of social well-being within planetary boundaries. This approach argues that Industry 4.0 primarily focused on digitalization, artificial intelligence, and efficiency enhancement, while paying less attention to social justice and sustainability. Accordingly, Industry 5.0, by emphasizing the redefinition of the role of research and innovation in the long-term service of humanity, presents a distinct value-oriented vision (Xu et al., 2021:530). This new wave is founded upon three fundamental pillars: human-centricity, sustainability, and resilience, and it seeks to transform industry into a mechanism serving inclusive well-being. Within this framework, the objective of industry is no longer limited to increasing profit or reducing costs; rather, it encompasses improving the quality of life of all stakeholders (from workers and investors to society and the environment). Responsible innovation, commitment to social justice, and respect for environmental limits lie at the core of this approach. Beyond advantages such as attracting and retaining talent, optimizing energy consumption, and enhancing resilience, Industry 5.0 aims to secure its long-term competitiveness through active participation in the societal transition toward sustainability and human-centricity. Otherwise, neglecting this transition may pose a serious threat to the future of industry (European Commission, 2021). Despite this conceptual transformation, the practical reflection of this paradigm shift in the architectural design of factories remains challenging. If Industry 5.0 emphasizes placing humans at the center of the production process, then industrial spaces must move beyond a purely functionalist and technology-driven logic and evolve into meaningful, equitable, flexible, and sustainable environments. Factory architecture is no longer merely a setting for the installation of equipment; rather, it becomes a socio-spatial mechanism capable of enhancing the quality of work experience, sense of belonging, perception of justice, and environmental responsibility. In this context, the entry of Generation Z into the production arena a generation highly sensitive to social and environmental values, further intensifies the necessity of aligning architectural design with their value preferences. From this perspective, the principal challenge lies not in the conceptual acceptance of Industry 5.0, but in translating it into operational spatial and architectural indicators. Many factories continue to be designed based on previous models, whereas generational and social transformations demand a redefinition of the spatial quality of production environments. Accordingly, the present article, focusing on Generation Z, seeks to elevate the architectural design requirements of Industry 5.0 factories from the level of broad rhetoric to

the level of concrete spatial components, thereby taking a step toward aligning industrial architecture with the value-oriented paradigm of the fifth industrial wave.

Technological transformations in recent decades particularly in the form of advanced robotics, computer-integrated manufacturing, and cyber–physical production systems have fundamentally reshaped our understanding of industrial production. The emergence of Cyber–Physical Production Systems (CPPS) and the expansion of the concept of "smart manufacturing" have transformed factories into complex, data-driven environments. At the same time, alongside the utilization of these technological capacities, scholarly attention to the central role of workers within these systems has increased. In this regard, the approach of "Value Sensitive Design" has been proposed as a principled framework to demonstrate how technologies related to human–machine coexistence can be designed in alignment with human values. By providing practical steps for engineers and designers, this approach seeks to identify and manage the ethical and social implications of implementing emerging technologies and to facilitate the transition toward future symbiotic factories (Longo et al., 2020:2). This perspective provides a theoretical foundation for linking technology with human values in industrial environments. At a broader level, contemporary environmental and social challenges have highlighted the necessity of revising prevailing production models. The United Nations Sustainable Development Goals report indicates that despite certain advances, rising carbon emissions, accelerated climate change, land degradation, threats to biodiversity, and increasing food insecurity persist (United Nations, 2020). This situation demonstrates that a significant proportion of industries have not yet structurally integrated environmental and social sustainability into their business practices (Bocken & Short, 2021:3). Within this context, Industry 5.0 has emerged as a response to the shortcomings of the Industry 4.0 model an approach that, while emphasizing digitalization and artificial intelligence, has been criticized by some for paying insufficient attention to social justice and human well-being. According to the European Commission report, Industry 5.0 is not a linear continuation of Industry 4.0, but rather a forward-looking framework for the coexistence of industry with emerging societal needs and trends (European Commission, 2021). In this model, the industrial worker is no longer regarded as a "cost," but rather as an "investment" that enables corporate growth and development (European Commission, 2021). This shift in perspective necessitates investment in skills, well-being, and employee empowerment, thereby elevating the value of human capital. In this respect, Industry 5.0 is grounded in three intertwined values human-centricity, sustainability, and resilience—and aims to transform industry into a resilient provider of well-being within planetary boundaries (Xu et al., 2021). This approach considers the development of circular processes, waste reduction, resource efficiency enhancement, and the strengthening of industry's responsiveness to political and natural crises as essential objectives. In terms of the workforce dimension, Industry 5.0 seeks to reconstruct the role of humans in production. The return of humans to the center of the system signifies a shift from repetitive manual tasks toward cognitive and value-adding activities, as well as effective collaboration with collaborative robots (cobots) (Longo et al., 2020). This human–machine collaboration, which some consider a defining characteristic of the new industrial era, presents Industry 5.0 as a greener and more human-centered version of Industry 4.0 (Gugercin & Gugercin, 2021). Furthermore, this transformation is regarded as an effort to address the human consequences of the Fourth Industrial Revolution and to integrate social and environmental concerns into technological innovations (Lachvajderová et al., 2023). Despite these developments, research indicates that in the fourth wave of industry, limited attention was given to the actual role of shop-floor work-

ers in the effective implementation of emerging technologies (Souza et al., 2022). In contrast, Industry 5.0 prioritizes the creation of safe, inclusive, and supportive work environments, placing physical and mental health, human dignity, and privacy at the forefront, and recognizing the enhancement of skills and work–life balance as essential (European Commission, 2021). Moreover, for younger workforce generations particularly Generations Y and Z, who have grown up in the digital age, social and environmental values have gained increasing importance in workplace selection. Evidence suggests that these generations prioritize sustainability, justice, and corporate social responsibility over salary or job security (European Commission, 2021). Such a shift in value orientations carries direct implications for the organization of workspaces and industrial environments.

Finally, it should be noted that the workplace is a setting in which individuals spend a significant portion of their lives, and it can influence users' behavior, health, ethics, and productivity (Loftness et al., 2003). From this perspective, factory architecture is not merely a container for technology deployment, but an active factor in shaping human experience, the quality of interactions, and the perception of justice and well-being within production environments. A synthesis of prior studies indicates that although Industry 5.0 conceptually emphasizes human-centricity and sustainability, the linkage between these concepts and the spatial requirements and architectural design of factories particularly in relation to the value preferences of Generation Z still requires systematic elaboration; a gap that the present article seeks to address.

Methodology

This article is applied in nature; applied research seeks to provide a solution to a significant issue within society or industrial organizations. By "issue," it does not merely refer to a defect or malfunction, but encompasses the expansion of knowledge and the enhancement of our understanding of a complex phenomenon (Kumar, 2008). In this study, the central issue is the elucidation of architectural design requirements for Industry 5.0 factories based on the value preferences of Generation Z within contemporary production environments. The methodological strategy is mixed (qualitative–quantitative). The adoption of a mixed approach was not merely for the sake of methodological diversity, but with the aim of deepening the analysis; as the outcome of one method can contribute to the expansion or enrichment of other methods (Greene et al., 1989), and through the integration of approaches, different levels or units of analysis can be clarified more effectively (Tashakkori, 2003). Within this framework, the qualitative phase led to the extraction and formulation of the theoretical components of Industry 5.0 architecture, while the quantitative phase was devoted to the empirical testing and prioritization of these components in practice. In the first stage, relying on library-based studies and a systematic review of specialized literature, the factors influencing the design of fifth-generation industrial complexes were identified and organized into conceptual dimensions. This stage resulted in the development of an initial conceptual model grounded in the three fundamental components of Industry 5.0 human-centricity, sustainability, and resilience which formed the basis for designing the measurement instrument. second stage, the research instrument was developed in the form of a structured questionnaire. Surveys acquire meaning in applied research when they are capable of collecting the perceptions, interpretations, lived experiences, and evaluations of the principal actors of a system in relation to theoretical components (Neuman, 2014). In this article, the principal actors are Generation Z employees in industrial environments, whose lived experience of production spaces is considered the criterion for assessing the degree of alignment between factory architecture and the values of Industry 5.0.

A cross-sectional survey method was em-

ployed; particularly in studies of industrial environments, this method is regarded as one of the most valid empirical approaches due to its ability to collect standardized data from large groups and to provide a degree of generalizability (Fink, 2013). To maintain instrument coherence while enabling comparative analysis, a single unified questionnaire was designed, yet occupational positions were differentiated within it to allow for the examination of perceptual differences among various work groups (Bryman, 2016). The content validity of the instrument was examined through expert evaluation, followed by a pilot implementation and cognitive interviews to review the conceptual clarity and coherence of the items. After the final administration of the questionnaire in production environments, the collected data were analyzed using descriptive and inferential statistical methods. To assess the dimensional structure of the model, exploratory and confirmatory factor analyses were conducted. Subsequently, the prioritization of architectural components was performed based on the level of perceived importance among Generation Z. This process enabled the identification of existing gaps between the theoretical framework of Industry 5.0 and the actual preferences of the younger workforce generation.

Generation Z and Generational Characteristics in the Context of Work and Contemporary Society

Generation Z (born between 1997 and 2012) faces a complex and intertwined set of challenges during the transition to adulthood challenges shaped by pervasive digital connectivity, economic uncertainties, and global environmental threats (Ambhore, 2025). This generation is the first to be fully immersed in digital culture, and its lived experience is defined by smartphones, online learning, and virtual interactions. While such a lifeworld has provided opportunities such as rapid access to information and new forms of civic engagement, it has simultaneously exposed them to emerging stressors including continuous social comparison, digital fatigue, cyberbullying, fear of missing out (FOMO), and information overload. Demographic profiles indicate that Generation Z is the most racially and ethnically diverse generation in many countries, and its identity is deeply intertwined with digital nativity. This generation constitutes nearly 30 percent of the global population and, according to United Nations demographic projections, as it enters adulthood, it represents a significant share of the global workforce. Distinctive characteristics of this generation include independence, entrepreneurial spirit, altruism, intrinsic motivation, and at the same time a shorter attention span, traits that influence how they interact with the workplace, acquire new skills, and engage socially (Jayatissa, 2023). From a psychological and social perspective, studies have highlighted a wide range of negative outcomes such as sleep disturbances, attention difficulties, and challenges in emotional regulation associated with the conditions under which this generation has grown up. One emerging stressor among this cohort is climate anxiety a phenomenon defined as persistent fear or distress regarding environmental degradation and future insecurity, intertwined with broader concerns about economic instability and career prospects (Ambhore, 2025). This environmental sensitivity, alongside altruistic tendencies, reflects the importance of social justice, sustainability, and cultural inclusion within their value system (Jayatissa, 2023:184).

In the employment domain, Generation Z has become a focal point for employers, as this generation has experienced technological change not as a temporary transformation but as a constant element of their professional lives. Studies indicate that they show a considerable preference for working in technological fields, with more than half expressing a desire to be employed in the technology sector (Jayatissa, 2023). As digital natives, Generation Z employees demonstrate high adaptability to artificial intelligence–based tools, automation, and collaborative digital platforms, and they perceive the use of such tools as enhancing productivity and streamlining work-

flows (Shinde & Surve, 2025).

From the perspective of job expectations, this generation places particular emphasis on flexibility in work arrangements. Unlike previous generations that were accustomed to fixed and hierarchical structures, Generation Z prefers hybrid work models, remote work, and autonomy in scheduling. Meaningful job characteristics such as autonomy, skill variety, and task significance play a decisive role in their intention to remain within an organization. Alongside flexibility, transparency and fairness in compensation systems are also primary priorities; they regard equitable pay and financial stability as key factors in job satisfaction and retention.Generation Z also prioritizes rapid career advancement and continuous skill development. Unlike older generations that valued long-term stability, this generation expects clear growth pathways, ongoing learning opportunities, and professional mentoring, and in the absence of such conditions, they demonstrate a greater tendency to change jobs. They prefer microlearning, gamified platforms, and self-directed digital courses over traditional training, and at the same time show resistance to repetitive and monotonous tasks; they expect creativity, problem-solving, and automation to replace routine processes. Ultimately, the communication styles of Generation Z differ significantly from those of previous generations. They prefer informal, real-time, and technology-based communication environments, within which they experience a greater sense of effectiveness and participation (Shinde & Surve, 2025). These communication patterns and professional expectations, together with environmental and social concerns, portray a generation that simultaneously seeks meaning, flexibility, justice, rapid advancement, and organizational alignment with social and planetary values.

The Impact of the Work Environment on Job Satisfaction and Employee Performance

Employee satisfaction and well-being are key factors in enhancing motivation, productivity, and performance. A desirable and safe work environment enables employees to perform their duties in the best possible manner, with a positive spirit and a sense of job security, thereby generating significant added value for the organization (El-Zeiny, 2012). Research indicates that job satisfaction is associated with a sense of security, and workers who are satisfied with their jobs demonstrate better performance (Bockerman & Ilmakunnas, 2012). Affective Events Theory also suggests that workplace events and conditions can generate positive or negative emotions, thereby influencing organizational commitment, performance, and job satisfaction (Karugu & Kiiru, 2019). A comfortable and supportive work environment plays a significant role in improving employees' attitudes, behavior, and performance (Atmaja, 2018), whereas the failure to meet welfare needs can lead to psychosocial maladjustment and stress-related illnesses (Heerwagen, 1998). Therefore, applied research seeks solutions that not only address practical organizational issues but also contribute to the development of knowledge regarding workplace improvement and the enhancement of employee satisfaction (Kumar, 2008:59). The integration of quantitative and qualitative data further enriches findings and clarifies different levels of analysis within the workplace (Greene et al., 1989).

Extraction of Architectural Components of the Production Sector in Industrial Complexes

Based on a systematic review of the literature in the fields of industrial architecture, Industry 5.0, human-centered production environments, and studies related to sustainability and spatial flexibility, a set of key design components for the production sector in heavy industries was identified. These components can be classified into three principal dimensions:

Patterns of Ownership and Utilization of Production Space

Findings from the literature indicate that within the Industry 5.0 paradigm, production space is no

longer merely a physical setting for the installation of machinery, but rather an interactive environment adaptable to new patterns of teamwork and multi-skilling. In this regard, the following components were extracted: the formation of independent production units to strengthen multi-skilling and operational self-management; spatial organization for small work groups to enhance a sense of belonging and responsibility; the placement of small-scale and dispersed service functions near workstations; provision of easy access to welfare facilities at a human scale; the possibility of rapid and flexible positioning of industrial equipment; the use of digital boards with simple and comprehensible signage; and the smartification of processes accompanied by intelligent monitoring and supervision systems. These elements reflect a transition from a centralized and hierarchical factory model toward modular, adaptable, and user-centered production environments.

Technical, Technological, and Energy-Related Considerations

At the technical and infrastructural level, the literature emphasizes the convergence of environmental sustainability, human comfort, and energy optimization. The extracted components include: the use of renewable energy sources and natural materials instead of unsustainable fossil resources; personalized control of temperature and humidity rather than uniform centralized systems; targeted lighting design with maximum utilization of daylight; effective systems for the removal of unpleasant odors and fumes; reduction of noise pollution and disruptive sounds; mitigation of thermal fluctuations through materials with high thermal mass; provision of exposed and upgradable installations; the use of light colors at a macro scale and specific colors for particular spaces; application of durable and recyclable materials; and the design of ventilation systems based on personal monitoring. These findings indicate a shift in perspective from the "factory as a production machine" to the "factory as a healthy and sustainable working environment."

Spatial Planning and Functional Organization

At the level of spatial organization, the literature highlights flexibility, scalability, and efficiency of production flow. The most significant extracted components include: spatial flexibility with the capacity for expansion and support of diverse functions; design of geometry and form based on sustainable architecture and optimization of functional pathways; spatial organization according to the production cycle and interdepartmental interactions; definition of access hierarchies based on function; creation of rapid and efficient connections between units; and the design of expandable structures with minimal physical barriers. This dimension underscores the importance of scalability and spatial readiness for technological and organizational changes in next-generation factories.

In summary, the literature indicates that the architecture of the production sector in industrial settings, within the framework of Industry 5.0, must simultaneously address three levels: "human-centered utilization," "technical–energy sustainability," and "spatial–structural flexibility." These three axes form the initial framework of the conceptual model of the present study and served as the foundation for the design of the measurement instrument.

Analysis of Productive Architectural Features in Relation to Generation Z

In this research, an attempt has been made to leverage modern approaches in industrial architecture to identify features that not only optimize production efficiency but also align with the psychological and value-based requirements of Generation Z. These features are categorized in Table 1 as "Productive Architectural Features." As demonstrated in Table 1, these components serve as more than just technical instruments for increasing output; they act as a foundational framework for addressing the needs of

Generation Z within industrial environments. This generation, characterized by traits such as "digital-nativity," "a focus on mental health," "environmental awareness," and a "desire for personalization," seeks a work environment that is, on one hand, integrated with smart technologies (Digital Infrastructure) and, on the other hand, provides a human-centered and ergonomic space (Human-Centered & Ergonomic Design) that minimizes environmental stress.

Consequently, the implementation of the components outlined in Table 1 fosters a "responsive architecture." In this setting, Spatial Flexibility and Modular Layout provide the necessary foundation for the dynamism expected by this generation. Ultimately, this approach creates a sustainable balance between the hardware goals of industrial production and the software-driven expectations of the Generation Z workforce.(Tab. 1)

Table 1: Extracted Productive Architectural Features and Their Relationship with the Main Research Dimensions

No.	Productive Architectural Feature	Operational Definition	Research Dimension	Supporting Studies	Relationship with Generation Z (Gen Z) Preferences & Behaviors
1	Spatial Flexibility	Reconfiguration of production layouts with minimum interruption	Spatial Planning & Functional Organization	Goodini & Vafamehr (2019, p.85); Lachvajderová et al. (2023, p.128)	Aligns with Gen Z's adaptability and aversion to rigid, hierarchical structures.
2	Optimized Workforce Flow	Efficient movement and interaction of workers	Spatial Planning & Functional Organization	Shahcheraghi & Bandarabad (2015)	Creates an organized, transparent, and low-stress environment, contributing to mental well-being.
3	Human-Centered Design	Enhancing workers' comfort, health and satisfaction	Technical, Technological & Energy Issues	European Commission (2021, p.15) ;Tiwari(2020, p.462)	Prioritizes individual psychological and welfare needs, a core value for Gen Z in work.
4	Ergonomic Workplace Design	Workstations adapted to human capabilities	Technical, Technological & Energy Issues	Schultz (2014, p.530); Chandrasekar(2011)	Emphasizes long-term health and work-life quality, a key concern for this generation.
5	Human–Robot Collaboration	Safe cooperation between workers and intelligent robots	Technical, Technological & Energy Issues	Nahavandi (2019, p.3); Demir et al. (2019,p.693)	Facilitates acceptance of technology as supportive tools, mitigating anxiety about automation.
6	Digital Infrastructure	Smart monitoring through IoT and sensors	Technical, Technological & Energy Issues	Xu et al. (2021, p.530); Longo et al. (2020, p.7) ; Gugercin & Gugercin(2021, p.526)	Caters to Gen Z's digital nativity, demanding transparency and data-driven insights.
7	Digital Infrastructure	Smart monitoring through IoT and sensors	Technical, Technological & Energy Issues	Xu et al. (2021, p.530); Longo et al. (2020, p.7);Gugercin & Gugecin(2021, p.526)	Caters to Gen Z's digital nativity, demanding transparency and data-driven insights.
8	Energy Efficiency	Reducing energy consumption through architectural and technical solutions	Technological & Energy Issues	European Commission (2021, p.16); Demir & Ciciba̧ (2019, pp.6–7) ; Ghobakhloo et al. (2022)	Reflects responsibility towards the environment and global sustainability concerns.

9	Environmental Sustainability	Waste reduction and resource optimization	Technical, Technological & Energy Issues	European Commission (2021, p.16); Demir & Cicibaş (2019, pp.6–7);Mattila et al. (2022, p.175)	Aligns with Gen Z's ethical values regarding resource conservation and waste minimization.
10	Safety-Oriented Spatial Design	Reducing occupational risks through spatial planning	Technical, Technological & Energy Issues	Karugu & Kiiru (2019, p.336)Breque et al.(2021, pp.8-11)	Prioritizes physical and psychological safety, reducing environmental anxieties in the workplace.
11	Future Expandability	Accommodating future technologies and capacity growth	Ownership & Space Utilization Patterns	Peters & Timmerhaus (2014, p.99); Goodini & Vafamehr (2019, p.86)	Demonstrates a future-oriented perspective, valuing environments with growth potential.
12	Mass Personalization Capability	Flexible production for customized products	Ownership & Space Utilization Patterns	Ostergaard (2018, pp.4–8)	Appeals to Gen Z's appreciation for individuality and desire for products/processes that cater to diverse preferences.
13	Mass Personalization Capability	Flexible production for customized products	Ownership & Space Utilization Patterns	Ostergaard (2018, pp.4–8)	Appeals to Gen Z's appreciation for individuality and desire for products/processes that cater to diverse preferences.
14	Spatial Resilience	Maintaining operational performance under disruptions	Ownership & Space Utilization Patterns	Xu et al. (2021, p.533); Rijwani et al. (2024, p.4)	Addresses an awareness of disruptive risks (crises, market shifts); ensures continuity of work and production.
15	Integration of Architecture and Smart Technologies	Alignment of architectural design with intelligent production systems	Ownership & Space Utilization Patterns	Longo et al. (2020, p.7); European Commission (2021, p.13)	Creates an intelligent, seamless, and engaging user experience within the physical space.

FINDINGS AND DISCUSSION

Following the extraction of architectural components of Industry 5.0 factories through literature review and the formulation of the initial conceptual model, this stage evaluated the empirical validity of these components within real industrial environments. The primary objective of this section was to measure the perceived importance of each design indicator from the perspective of Generation Z employees and to analyze their prioritization patterns.

Design and Implementation of the Cross-Sectional Survey Questionnaire

To empirically assess the components extracted from the literature, the research instrument was developed in the form of a structured questionnaire. In the first stage, based on a systematic review of literature related to fifth-generation industrial architecture, human-centric industry, and sustainable production environments, 70 items were identified as influential indicators in the architectural design of the production sector and were structured using a Likert scale.

Stage One: Content Validity Assessment To examine the content validity of the instrument, the initial questionnaire was submitted to five experts in the fields of industrial architecture and production environment design. At this stage, each item was evaluated according to the criteria

of "relevance to the conceptual construct," "clarity of expression," and "necessity of inclusion in the instrument."

The items were classified into three categories: acceptable, requiring revision, and unacceptable.

Based on expert feedback, a total of 20 items were identified as requiring revision and were rewritten in terms of sentence structure or conceptual precision. Additionally, 5 items were removed due to conceptual overlap or weak alignment with the theoretical framework, and 5 new items were proposed as replacements and added to the instrument. At the conclusion of this stage, the revised version of the questionnaire consisted of 70 items.

Stage Two: Pilot Study and Cognitive Interview

In the second stage, in order to assess conceptual clarity, linguistic simplicity, and comprehensibility of the items, the 70-item questionnaire was administered as a pilot study to 15 individuals from the target statistical population. Simultaneously, cognitive interviewing was employed to identify potential ambiguities in respondents' interpretations.

The results of this stage led to the following revisions:

•Rewriting of 5 items to simplify sentence structure;

•Replacement of specialized terminology in 4 items with more general and comprehensible equivalents;

•Addition of brief examples or explanations to 2 items to clarify specific concepts.

These revisions were undertaken to reduce interpretive error, increase response accuracy, and enhance the validity of the instrument.

Final Survey Administration

In the final stage, the finalized questionnaire was distributed to and collected from 307 employees in an automotive production environment. This stage was conducted as a cross-sectional survey, and the collected data formed the basis for the statistical analyses presented in the findings section.

Sample composition and generational scope. The realized sample comprised 307 production employees of an automotive manufacturing complex (operators 68.1%, technicians 19.5%, engineers 12.4%). Reported work experience in the automotive industry ranged from 1 to 30 years (mean = 13.3; median = 11), and respondents' age or year of birth was not recorded. The sample therefore reflects the contemporary production workforce across several age cohorts rather than an exclusively Generation Z group. Accordingly, the empirical priorities reported below are treated as the spatial preferences of current production personnel and are interpreted in light of Generation-Z-oriented literature, with the generational composition of the sample acknowledged as a limitation. The composition and percentage distribution of the participants' job positions are presented in (Tab. 2).

Table 2: Job Positions of the Participants

Positions	Percentage (Number)
Operator	68.1% (209)
Technician	19.5% (60)
Engineer	12.4% (38)
Unreported values	0%

The educational level of the questionnaire participants is presented in (Tab. 3).

Table 3: The educational level of the questionnaire participants

Education Level	Percentage (Number)
Diploma / Below Diploma	55.0% (169)
Associate Degree	20.5% (63)
Bachelor's Degree	18.2% (56)
Master's / PhD	6.2% (19)

To examine the discriminative power of the developed test, the lowest 25% and highest 25% of the obtained scores were selected, and an independent-samples t-test was conducted. The analyses indicated a significant difference between the upper- and lower-threshold scores of the test, and Cohen's d effect size suggested that the discriminative power of the test was very satisfactory

($t = -25.75$, $df = 133.92$, $p < 0.001$, $|d| = 4.09$). For item analysis, item–total correlations were calculated for all items. The results showed that eight items had item–total correlations below 0.2, indicating poor alignment with the other items in the test. Removing these items would also increase the Cronbach's alpha of the test; therefore, it was decided to exclude these items from the analysis. The overall Cronbach's alpha for the test was 0.920, indicating very satisfactory internal consistency. In addition, a direct reliability analysis of the 49 attitudinal-intensity indicators retained for the descriptive prioritization, computed on the full realized sample ($n = 307$), yielded a Cronbach's alpha of 0.94, confirming excellent internal consistency of the measured scale.

To assess the feasibility of conducting exploratory factor analysis (EFA) on the test data, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used. Both indices yielded desirable values, confirming the suitability of the data for EFA. Before conducting the exploratory factor analysis (EFA), the suitability of the data for factor analysis was assessed using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The analysis was conducted on the initial set of 70 items. The KMO value was 0.886, indicating a high level of sampling adequacy. Bartlett's test of sphericity was statistically significant ($\chi^2 = 4766.207$, $df = 1596$, $p < 0.001$), indicating that the correlation matrix differed significantly from an identity matrix. These results confirmed the suitability of the data for factor analysis and supported proceeding with the EFA. The results are presented in Table 4. (Tab. 4)

Table 4:KMO & Bartletts test

Kaiser–Meyer–Olkin Measure of Sampling Adequacy	0.886
Bartlett's Test of Sphericity - Approx. Chi-Square	4766.207
df	1596
Sig.	0.000

Following the exploratory factor analysis, confirmatory factor analysis (CFA) was conducted using LISREL 8.50 on the study sample ($N = 307$) to assess the measurement structure identified through the EFA. The initial CFA model included the 70 items retained for the initial factor structure and was estimated using the maximum likelihood method.

The initial model indicated areas requiring further examination, particularly in terms of the comparative and absolute goodness-of-fit indices. Accordingly, factor loadings, item-level diagnostics, and model modification information were reviewed. Based on statistical evidence and theoretical considerations regarding the conceptual consistency of the items with their respective factors, eight items were excluded from the measurement model. The revised

model, comprising 62 items, was subsequently re-specified and re-estimated. As reported in Table 5, the re-estimated model showed an improvement in the overall pattern of goodness-of-fit indices compared with the initial specification. The revised fit indices were considered collectively in evaluating the adequacy of the measurement structure rather than relying on any single index. The final model was subsequently used for the analysis of Generation Z's priorities regarding the architectural requirements of Industry 5.0 factories. (Tab. 5)

Table 5: Goodness-of-Fit Indicators for the Model

Model fit indices	70 items	62 items
Chi-Square = (P = 0.0)	2777.12	1986.43
df	1378	1247
Root Mean Square Error of Approximation (RMSEA)	0.054	0.048
Comparative Fit Index (CFI)	0.88	0.93
Incremental Fit Index (IFI)	0.88	0.93
Standardized RMR	0.085	0.064
Goodness of Fit Index (GFI)	0.67	0.86

As shown in Table 5, the re-estimated model demonstrated improved goodness-of-fit compared with the initial model. The RMSEA decreased from 0.054 to 0.048, while the CFI and IFI increased from 0.88 to 0.93. The Standardized RMR also decreased from 0.085 to 0.064, and the GFI increased from 0.67 to 0.86. Overall, the revised model demonstrated an acceptable level of fit and provided support for the proposed measurement structure. The results of the confirmatory factor analysis indicate that the hypothesized model regarding the placement of items under the factors extracted from the exploratory factor analysis fits well (good fit) with the data obtained from the study sample; therefore, the model is confirmed.

Priorities of Production Section Architecture from the Perspective of Generation Z

Following the development of the theoretical framework, three main dimensions of production section architecture were identified: (1) patterns of ownership and utilization of space, (2) technical, technological, and energy considerations, and (3) spatial planning and functional organization. A cross-sectional survey was subsequently conducted to examine the perceived importance of the identified architectural indicators among Generation Z employees. The purpose of this analysis was to determine the relative priority assigned to each architectural indicator within the three dimensions. Empirical prioritization of architectural indicators. To move beyond the narrative ranking, the perceived importance of each architectural indicator was quantified from the survey responses. Ordinal responses were coded on their native scales, negatively worded items (noise, unpleasant odor, and work stress) were reverse-scored, and each indicator was rescaled to a common 1–5 metric (higher = greater perceived importance/quality). Table 7 reports the mean importance of the nine architectural dimensions, and Table 8 presents the full ranking of the 49 individual indicators (mean and standard deviation; n = 307). The grand mean across indicators was 3.39 (1–5 scale). (Tab. 6)

Table 6: Perceived importance of architectural dimensions, ranked (n = 307)

Rank	Architectural dimension	Items (k)	Mean importance (1–5)
1	Performance Outcomes	3	4.20
2	Attachment & Retention	3	3.76

3	Functional Fit	5	3.71
4	Flexibility & Adaptability	7	3.54
5	Collaboration & Social	4	3.43
6	Technology Integration	3	3.43
7	Autonomy & Control	3	3.33
8	Physical & Environmental	12	3.14
9	Human-Centered & Wellbeing	9	3.05

Table 7: Ranked perceived importance of individual architectural indicators (n = 307)

Rank	Architectural indicator	Dimension	Mean	SD
1	Space design affects production quality	Performance Outcomes	4.38	0.90
2	Optimized space would raise output	Performance Outcomes	4.21	0.89
3	Support spaces accessible	Physical & Environmental	4.19	1.02
4	Flexible space raises output/quality	Flexibility & Adaptability	4.15	0.97
5	Design affects intent to continue	Attachment & Retention	4.01	0.99
6	Optimization raises profitability	Performance Outcomes	4.00	1.02
7	Use of digital tools	Technology Integration	3.87	0.90
8	Sense of belonging/work identity	Attachment & Retention	3.85	1.15
9	Emergency exit route clarity/safety	Physical & Environmental	3.84	1.24
10	Space fits my work tasks	Functional Fit	3.80	1.06
11	Color/spatial coding aids function	Physical & Environmental	3.77	1.08
12	Spatial organization cuts errors	Functional Fit	3.77	0.89
13	Layout changes improve performance	Flexibility & Adaptability	3.72	1.10
14	Machine placement fits process	Functional Fit	3.69	0.73
15	Space supports product variety	Flexibility & Adaptability	3.69	1.08
16	Design eases equipment maintenance	Functional Fit	3.68	0.96
17	Visual wayfinding cues present	Physical & Environmental	3.67	1.02
18	Workspace color is pleasant	Physical & Environmental	3.64	1.06
19	Fast access to resources	Functional Fit	3.62	0.98
20	Culture supports collaboration/respect	Human-Centered & Wellbeing	3.58	1.11
21	Lighting adequacy	Physical & Environmental	3.57	1.20
22	Clear boundary of my workspace	Autonomy & Control	3.57	1.10
23	Space suits group interaction	Collaboration & Social	3.52	1.03
24	Layout enables knowledge sharing	Collaboration & Social	3.51	0.99
25	Design facilitates teamwork	Collaboration & Social	3.50	1.12
26	Design meets human needs	Human-Centered & Wellbeing	3.45	1.00
27	Willingness to stay in current job	Attachment & Retention	3.43	1.31
28	Design reduces physical/mental fatigue	Human-Centered & Wellbeing	3.42	1.11
29	Design keeps pace with new tech	Technology Integration	3.41	0.89
30	Space can scale up capacity	Flexibility & Adaptability	3.35	1.22
31	Product customization possible	Flexibility & Adaptability	3.31	1.23

32	Modular space design	Flexibility & Adaptability	3.30	1.01
33	Multi-purpose spaces exist	Flexibility & Adaptability	3.29	1.11
34	Space feels 'designed for me'	Autonomy & Control	3.28	1.12
35	Income satisfaction	Human-Centered & Wellbeing	3.28	0.98
36	Design considers individual differences	Human-Centered & Wellbeing	3.22	1.19
37	Space fosters creativity	Collaboration & Social	3.19	1.19
38	Psychological health considered	Human-Centered & Wellbeing	3.17	1.14
39	Right to modify/adjust workspace	Autonomy & Control	3.15	1.25
40	Can discuss problems with managers	Human-Centered & Wellbeing	3.02	1.24
41	Dining hall quality	Physical & Environmental	3.02	1.21
42	Training on new technology provided	Technology Integration	3.01	1.19
43	HVAC efficiency	Physical & Environmental	2.83	1.36
44	Outdoor/green space aids focus	Physical & Environmental	2.61	1.39
45	Psychological safety at work	Human-Centered & Wellbeing	2.48	1.26
46	Parking/drop-off quality	Physical & Environmental	2.47	1.28
47	Unpleasant odors (reverse) (reverse-scored)	Physical & Environmental	2.17	1.15
48	Noise is disturbing (reverse) (reverse-scored)	Physical & Environmental	1.85	0.99
49	Work stress/pressure (reverse) (reverse-scored)	Human-Centered & Wellbeing	1.81	1.01

Patterns of Ownership and Utilization of Space

The results show that the highest-prioritized indicators within this dimension were primarily associated with sense of belonging, spatial justice, equal access to facilities, and transparency in spatial allocation. These indicators received higher levels of perceived importance compared with other indicators within the same dimension.

The findings indicate that the following spatial characteristics were among the most highly prioritized:

-allocation of space according to functional requirements and actual user needs;

-equitable access to rest, interaction, and service facilities;

-transparency in the allocation and use of workplace spaces; and

-spatial characteristics that support employees' sense of belonging and participation.

Overall, the results demonstrate that indicators related to equitable spatial access and belonging occupied a prominent position within the dimension of ownership and utilization of space.

2. Technical, Technological, and Energy Considerations

Within the technical, technological, and energy dimension, the highest-prioritized indicators were associated with environmental quality, workplace safety, and energy performance. In particular, the results identified the following indicators as having relatively high importance:

-ventilation quality and control of thermal conditions;

-access to natural light and adequate artificial lighting;

-noise reduction and acoustic control;

-technical and physical safety in the workplace; and

-optimization of energy consumption.

The ranking of these indicators indicates that environmental quality, safety, and energy-related characteristics constituted the most prominent priorities within this dimension.

3. Spatial Planning and Functional Organization

Within the dimension of spatial planning and functional organization, the highest-prioritized indicators were related to spatial legibility, flexibility, interaction, learning opportunities, and reduction of functional conflicts. The most highly prioritized characteristics included:

-readability and accessibility of circulation paths;

-flexibility and adaptability of workspaces;

-provision of opportunities for interaction and on-the-job learning; and

-reduction of functional conflicts, congestion, and unnecessary spatial interference.

These results indicate that flexibility, spatial legibility, and opportunities for interaction and learning were among the dominant priorities within the spatial planning and functional organization dimension. Overall, the cross-sectional survey identified three broad groups of architectural priorities among Generation Z employees in production environments:

1.Ownership and utilization of space: spatial justice, equitable access, transparency, and sense of belonging;

2.Technical, technological, and energy considerations: environmental quality, workplace safety, and energy performance; and

3.Spatial planning and functional organization: flexibility, spatial legibility, interaction, learning opportunities, and reduction of functional conflicts.

These findings establish the empirical basis for the subsequent discussion of the underlying values and expectations reflected in Generation Z's architectural priorities. Their theoretical interpretation, comparison with previous studies, and implications for Industry 5.0 -oriented architectural design are discussed in Section 5.

RESULTS AND CONCLUSION

The findings presented in Section 4-2 indicate that Generation Z's assessment of production-sector architecture extends beyond conventional functional and technical requirements. The identified priorities reflect a broader set of human, social, environmental, and adaptive values that shape how this generation perceives the workplace. Therefore, the significance of these findings cannot be fully understood through their statistical ranking alone. Their interpretation requires consideration of the underlying values identified in the theoretical framework, particularly those associated with Value Sensitive Design (VSD) and the human-centric, sustainable, and resilient principles of Industry 5.0.

Accordingly, this section moves beyond the reporting of empirical priorities and interprets their underlying meaning, compares the findings with previous research, and examines possible explanations for convergent, divergent, or unexpected results. The discussion then translates these interpretations into architectural implications and design strategies for Industry 5.0 production facilities. Finally, the limitations and boundary conditions of the findings are discussed to clarify the extent to which the results can be interpreted and generalized.

Interpretation of Generation Z's Architectural Priorities in the Context of Value Sensitive Design and Industry 5.0

The findings suggest that Generation Z evaluates production environments not only through functional efficiency but also through human, social, environmental, and adaptive values. From a Value Sensitive Design (VSD) perspective, priorities such as spatial justice, equal access, transparency, and sense of belonging reflect values of fairness, inclusion, dignity, and participation. These findings reinforce the human-centric orientation of Industry 5.0 by indicating that spatial organization can influence employees' perception of inclusion and organizational identity.

The emphasis on environmental quality, safety, and energy efficiency further indicates that workplace architecture is perceived as a means of supporting both human well-being and environmental responsibility. Ventilation, thermal comfort, lighting, acoustic quality, and safety can therefore be interpreted not merely as technical

requirements but as spatial expressions of health, comfort, and dignity, while energy efficiency connects these concerns to the sustainability pillar of Industry 5.0.

Similarly, the importance of flexibility, interaction, spatial legibility, and learning opportunities reflects the need for production environments that can adapt to changing work processes and technologies. These priorities connect human-centered values with the resilience dimension of Industry 5.0. Overall, the findings indicate that Generation Z's architectural expectations represent an integrated demand for fair, healthy, sustainable, and adaptable production environments, rather than isolated spatial features.

Comparison with Previous Studies and Interpretation of Unexpected Findings

The findings are broadly consistent with previous studies emphasizing human-centered workplace conditions, environmental quality, flexibility, interaction, and opportunities for learning. However, the qualitative evidence from the present study also revealed several findings that provide a more nuanced understanding of Generation Z's expectations in heavy industrial workplaces. These observations were derived from the analysis of five open-ended questions in the user questionnaire, interviews with participants, and subsequent open coding of the qualitative responses. They therefore complement the quantitative priorities reported in Section 4-2 rather than constituting independent generalizations about Generation Z. Several findings challenge common assumptions about younger employees' workplace priorities. First, the qualitative responses suggest that financial benefits are not necessarily perceived as the primary criterion of workplace value. Participants in several cases placed greater emphasis on the overall development and improvement of the organization than on benefits that would directly increase their individual financial returns. Similarly, rather than viewing the workplace primarily as a means of satisfying financial expectations, participants emphasized the importance of being valued, supported, and recognized within the work environment. This finding challenges a purely extrinsic interpretation of Generation Z's workplace expectations and highlights the importance of organizational belonging and human recognition.

Second, the qualitative findings indicate a preference for active participation in problem-solving, teamwork, and creative activities, rather than being restricted to repetitive and narrowly defined tasks. Participants also expressed interest in more varied work experiences and environments. This finding helps explain the quantitative emphasis on flexibility, interaction, learning, and spatial organization, suggesting that architectural environments can either reinforce repetitive work patterns or provide opportunities for collaboration, learning, creativity, and greater employee agency.

A further finding concerns environmental responsibility. The qualitative responses indicated a relatively strong interest in environmental issues and a preference for workplaces that demonstrate environmental responsibility. This observation reinforces the sustainability dimension of Industry 5.0 and suggests that environmental values may influence employees' perceptions of workplace quality in addition to organizational policies and technical performance.

These findings have direct architectural implications. If employees value participation, recognition, creativity, and organizational belonging, production environments should provide spatial opportunities for teamwork, informal interaction, learning, creative problem-solving, and varied work experiences. Similarly, perceptions of organizational care can be reinforced through equitable access to welfare facilities, high-quality environmental conditions, and spaces that support social interaction and belonging. Environmental preferences can also be translated into architectural strategies such as daylight utilization, energy-efficient systems, sustainable materials, environmental monitoring, and improved indoor environmental quality. Thus, the qualitative find-

ings extend the interpretation of Generation Z's priorities from employment preferences to the spatial and environmental conditions through which these values can be experienced in the workplace.

Architectural Implications and Design Strategies for Industry 5.0 Production Facilities

The findings of this study were translated into architectural implications and design strategies for Industry 5.0 production facilities. To demonstrate how the identified concerns and values of Generation Z can be reflected in the physical organization and environmental qualities of industrial workplaces, the proposed architectural responses are presented through Table 6 and four complementary architectural diagrams. Together, these representations illustrate the proposed transformation at different spatial scales, from the overall organization of the production complex to the configuration of individual production units, the diversity of workplace environments, and the environmental performance of the factory. (Tab. 8)

Table 8: Alignment Between Analytical Findings (Gen Z Concern) and Architectural Design Strategies in Industry 5.0 Production Facilities

Proposed Design Strategies	Spatial Interpretation	Analytical Finding (Gen Z Concern)	Architectural Dimension
Ownership and Spatial Governance Patterns	Need for participation and visibility	Preference for active involvement and avoidance of spatial anonymity	Small workgroups fostering a sense of belonging; Semi-autonomous production units supporting multi-skilled workers
	Spatial equity and respect for diversity	Sensitivity to spatial hierarchy and perceived inequality	Personality-based spatial design; Decentralized and proximate service facilities
	Social interaction and collective identity	Importance of informal and network-based communication	Dedicated social interaction zones; Human-scaled production clusters
Technical, Technological, and Energy Considerations	Environmental health and physical well-being	Direct impact of environmental quality on job satisfaction	High-quality ventilation systems; Acoustic monitoring and noise control; Task-oriented lighting with maximum daylight integration
	Environmental responsibility and sustainability	Concern for ecological impact of industrial production	Use of durable and recyclable materials; Waste reduction strategies; Resource efficiency optimization
	Human–technology collaboration	Acceptance of technology while preserving human agency	Use of durable and recyclable materials; Waste reduction strategies; Resource efficiency optimization
Spatial Planning and Functional Organization	Flexibility and adaptability	Rejection of rigid and static environments	Modular production lines; Multi-functional and reconfigurable spaces; Expandable structural systems with minimal physical barriers
	Meaningfulness of work and task diversity	Preference for creative and non-routine roles	Mass customization strategies; Creation of emerging human-centered roles within smart production systems

At the scale of the industrial complex, the proposed architectural model moves from a predominantly centralized and linear production structure toward a distributed and modular spatial organization. As shown in Figure 1, a central management and smart-monitoring structure provides overall supervision and coordination, while independent modular production units are organized around it. These production units are designed to remain expandable, allowing the architectural organization of the factory to accommodate changes in production capacity, technology, and operational requirements. Thus, modularity and expandability become important architectural mechanisms for enhancing adaptability and resilience. (Fig. 1)

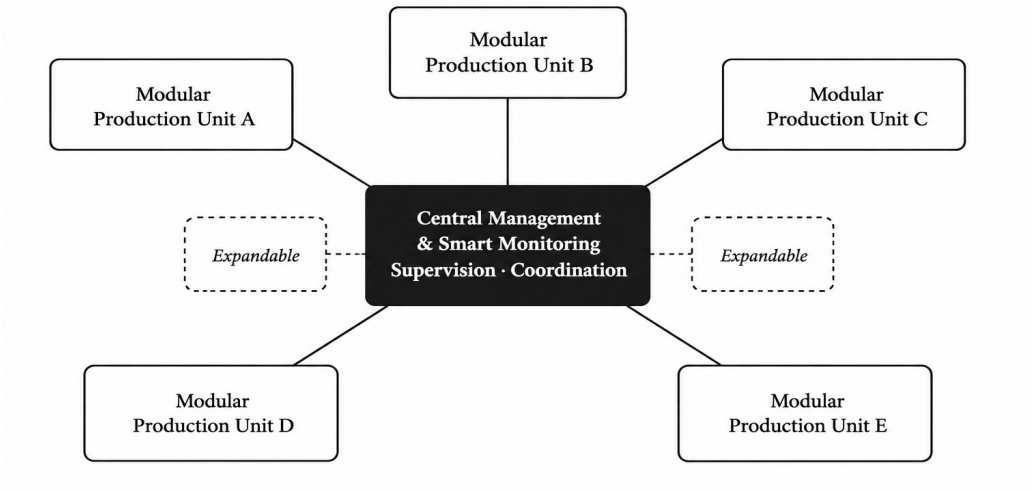


Figure 1: Modular and Expandable Spatial Organization of Industry 5.0 Production Facilities

At the scale of the individual production unit, the architectural organization extends beyond production stations to incorporate teamwork spaces, rest areas, welfare services, interaction and learning spaces, and flexible/reconfigurable areas. As illustrated in Figure 2, these spaces are integrated with the production environment to create a more human-centered architectural configuration. The proximity and functional relationship between production and supporting spaces can facilitate interaction, learning, recovery, and social belonging while maintaining the operational requirements of the production process. (Fig. 2)

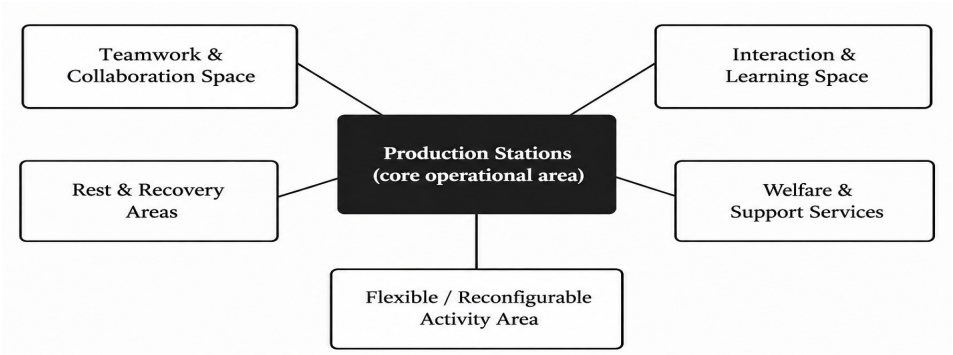
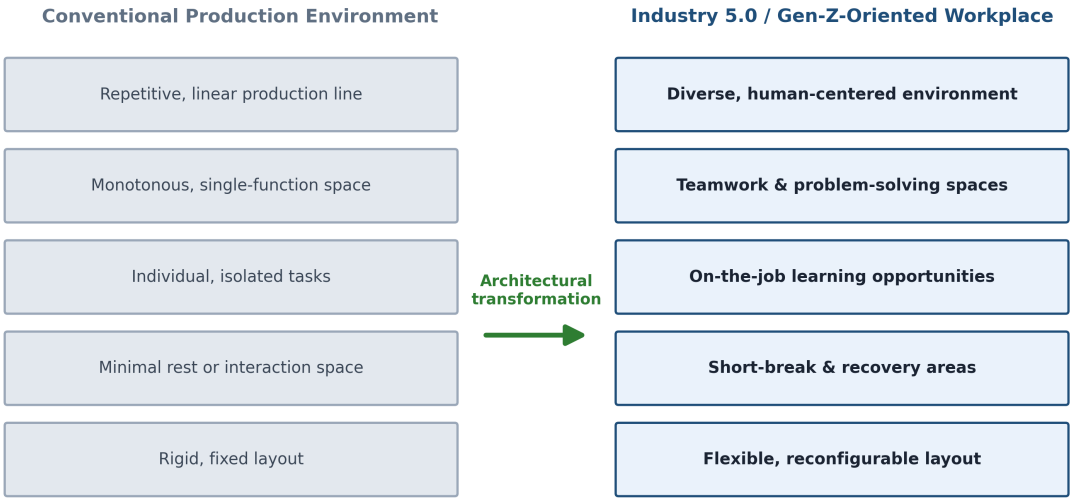


Figure 2: Architectural Organization of a Human-Centered Modular Production Unit

The transformation in the spatial experience of work is illustrated in Figure 3, which contrasts the architectural organization of conventional production environments with a workplace spatial model adapted to Generation Z. The figure demonstrates a shift from a repetitive and monotonous production environment toward a more diverse architectural environment that incorporates opportunities for teamwork, learning, short breaks, and problem-solving and innovation. Accordingly, architectural diversity and the provision of complementary activity spaces can reduce spatial monotony and support greater employee participation and engagement. (Fig. 3)

Figure 3: Transformation of the Production Workplace for Generation Z



Finally, Figure 4 illustrates the proposed architectural approach to creating a healthy, human-centered, and environmentally responsive production environment. The design integrates daylight and daylight-control systems, natural and smart ventilation, acoustic control, photovoltaic panels, green spaces, and durable and high-performance materials. Smart environmental sensors can also be incorporated to monitor air quality and detect undesirable odors, smoke, and other environmental conditions. These architectural and technological measures demonstrate how environmental quality, human well-being, and sustainability can be simultaneously addressed within the design of Industry 5.0 production facilities. (Fig. 4)

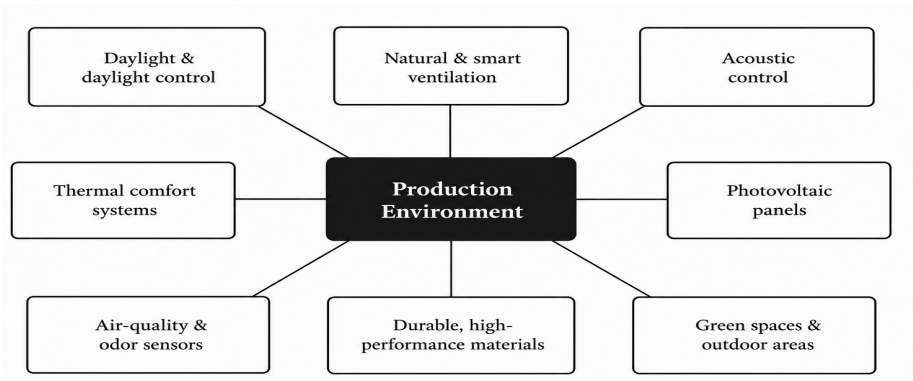


Figure 4: Architectural Strategies for a Healthy and Environmentally Responsive Production Facility

Taken together, Table 6 and Figures 1–4 demonstrate how the concerns identified among Generation Z can be translated into tangible architectural characteristics at different scales. The proposed approach therefore moves beyond conventional productivity-oriented industrial architecture toward a modular, adaptable, human-centered, and environmentally responsive architectural model that is consistent with the human-centricity, sustainability, and resilience principles of Industry 5.0. Sample size represents an important methodological limitation of this study. The CFA was conducted on a sample of 307 employees working in industrial production environments. Given the relatively limited representation of Generation Z in Iran's industrial workforce, obtaining a larger sample of eligible respondents was practically challenging. In addition, restrictions on field access and data collection during the period of armed conflict further constrained the researchers' ability to access industrial sites and recruit additional participants. These circumstances, combined with the limited accessibility of the target population, resulted in a realized sample of 307 respondents. Although the measurement model was re-examined and reduced from 70 to 62 items based on statistical and theoretical considerations, the respondent-to-item ratio remains modest relative to the complexity of the measurement model. Therefore, the findings should be interpreted with appropriate caution. Future studies should replicate and validate the proposed measurement structure using larger samples across a broader range of industrial sectors and geographical contexts in Iran. Several further limitations should be noted in interpreting the measurement results. The exploratory and confirmatory factor analyses were performed on the same respondent sample (N = 307) rather than on two independent samples; the confirmatory analysis should therefore be regarded as a re-specification check rather than independent cross-validation, and replication on a separate sample is recommended. A sample of this size is also modest for a measurement model of 62-70 items, so the factor solution and fit indices should be interpreted with caution and re-estimated on a larger sample. The item-discrimination analysis, which contrasted the upper and lower score groups, is an internal check computed on the same total score and does not by itself constitute independent evidence of construct validity. Finally, because the data are cross-sectional and based on self-reported perceptions, the reported priorities and relationships are associational rather than causal; future work should report the full factor-loading matrix and the ranked importance weights and test the framework using structural equation modeling on larger, probability-based samples. Generational scope of the sample. A further limitation concerns the characterization of respondents as Generation Z. The questionnaire did not record age or year of birth, and the observed work-experience distribution (1–30 years; mean 13.3) indicates a multi-generational production workforce rather than a generationally delimited sample. The quantitative priorities reported here should therefore be interpreted as the spatial preferences of the current automotive production workforce; their correspondence with Generation-Z values is established through the literature rather than by the composition of the sample. Future research focusing on generational differences should collect age/birth-year data and restrict or stratify the sample accordingly, ideally comparing cohorts within the same production setting.

This study aimed to identify and define the architectural design requirements of Industry 5.0 factories based on the value preferences of Generation Z. The theoretical framework assumed that the transition from Industry 4.0 to Industry 5.0 is not merely a technological shift but a paradigm change in the relationship between humans, technology, and space.The cross-sectional survey revealed that Generation Z's concerns in industrial environments extend beyond physical infrastructure to the quality

of lived experience within the workspace. Key priorities included: Sense of participation and visibility, Spatial justice, Environmental health, Functional flexibility, Constructive interaction with technology, Environmental responsibility, Professional growth opportunities. These findings indicate that Generation Z views the factory not merely as a workplace, but as a platform for professional identity formation, social value realization, and meaningful work experience. A comparative analysis with the three main architectural dimensions patterns of ownership and space utilization, technical/energy considerations, and spatial planning and functional organization showed that each of Generation Z's value-driven concerns can be directly translated into design strategies. Ignoring the generational preferences of the emerging workforce could reduce motivation, lower productivity, and weaken industrial competitiveness over time. Conversely, aligning factory architectural design with Generation Z's values enhances job satisfaction, employee performance, and advances the broader objectives of Industry 5.0, including human-centeredness, sustainability, and resilience.Ultimately, this study demonstrates that fifth-wave industrial architecture must move beyond the notion of production space as mere infrastructure and evolve into a human–technology ecosystem, in which humans are not peripheral to technology but central to design organization.

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