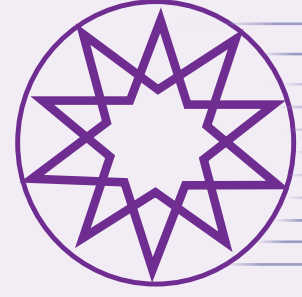


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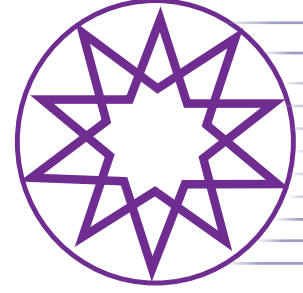
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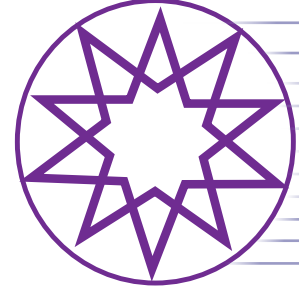
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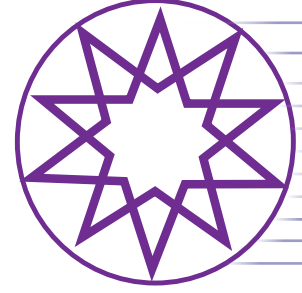
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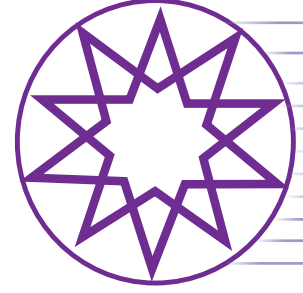
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M G A R O N

Article

Can one measure architectural contextuality? A simple “building similarity indicator”

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ABSTRACT

Adaptation of a building to the environment – often referred as “contextuality” – is considered a key quality of architecture. The assessment of such contextual coherence is frequently attributed to the perception and expertise of architects. This is generally appropriate, as coherence depends on multiple factors such as form, color, materials, landscape, professional knowledge about ideas and historical contexts and an assessment of the *genius loci*, often described as atmosphere. Nevertheless, there is increasing interest in quantifying such aspects, particularly in the context of sustainability assessments like Social Life Cycle Assessment (sLCA).

This paper explores and discusses an approach to “quantifying the quality” of contextuality. It proposes a simple, image-based method for assessing contextual suitability using “Google Lens”. The approach is as follows: Ten visually similar buildings are identified via “Google Lens” in relation to a specific reference building. The average distance between the physical locations of these search results and the location of the reference building is then calculated. This average distance serves as an indicator of whether comparable architectures are predominantly situated within the regional environment or dispersed over larger distances. The indicator is named the “Building Similarity Indicator” (BSI). The BSI was calculated for a dataset of 320 buildings. Data analysis shows significantly increasing BSI values depending on the estimated “modernity” of a building, representing a loss of geographical contextuality.

This highly oversimplified approach is ultimately discussed critically. It might offer no more than a quantifiable supplement to discussions on “contextuality.” As such, it is suggested as appropriate for playing a role in quantitative storytelling for planners, architects, or sustainability scientists. Furthermore, integration into sLCA for buildings is suggested. Geographical contextuality can be seen as triggering identity and the conservation of (parts of the) perceived cultural history of a place. Therefore, it possesses social value.

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INTRODUCTION: WHY RATE THE “UNMEASURABLE”?

Technical optimization often comes at the cost of emotional richness in architecture. A loss of architectural quality is a global concern. It can be explained by increasingly uniform

building styles. These are driven by the standardization and globalization of building materials, and by a growing, one-sided technical orientation in construction focused on goals such as energy efficiency, sound insulation, or fire protection. This results in a loss of cultural identity in architecture (Abel, 2012). Form follows engineering

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rationality, but it frequently does not follow individual or social meaning-making. Regional and familiar construction methods, materials, and forms are often completely disregarded.

In terms of industry and real estate business, we see a technically and economically determined approach to new buildings. In terms of architecture, we find an “object-centered” architectural language that is likewise detached from regional context. This is also how Swiss architect Gion A. Caminada described it in an interview: Caminada, who draws inspiration for his buildings from the vernacular architecture of Alpine villages in Switzerland, regards the ability of architecture to create *identity* and enable *spatial belonging* as essential. He therefore recommends that buildings incorporate many elements of their local context. He says: “It takes that quantum of near-sameness for identity enabling.” (Schoper 2016)

This article picks up on that idea. It asks whether contextuality as a quality might not also be simply measurable — and discusses the advantages and limitations of such a quantitative approach. The contextual and spatial appropriateness of architecture is a central research topic in the field. Whether this appropriateness can be measured is a question that continues to engage scholars, as discussed by Yücel & Arabacıoğlu (2023) in *Megaron*.

Before proposing a simple indicator for measuring such appropriateness, this article begins with a propaedeutic observation: any attempt to “measure” a phenomenon as complex as appropriateness inevitably risks overreach. That could even evoke memories of George Orwell’s novel 1984, where the state monitors citizens’ satisfaction, reducing their emotions to standardized, quantifiable data. Especially in the age of artificial intelligence, scientists must be wary of such tendencies to quantify qualities of life that, in their “depth”, can only be experienced personally and multimodally.

Is the attempt to quantify a quality an appropriate answer to a problem described as the loss of sensual and emotional values in planning and construction? Ironically, maybe. Yet it is not only technological possibilities but also the requirements set by the state or certification bodies like LEED, BREAM or DGNB that compel us to engage with such approaches. This text addresses such engagement using the example of assessing the local “appropriateness” of buildings, named contextuality or “contextual compatibility” (Groat, 2024). The endeavor to make a complex matter very simple deserves skepticism. It is a double-edged undertaking, but one with charm and precedents. A good example is the *Big Mac Index*: The price of a Big Mac in a given country serves as a useful indicator for assessing purchasing power parity between nations (Ong, 2003; Clements & Si, 2017; Akarsu et al., 2024). What is a dollar worth compared to a peso or a euro—how

many Big Macs can you get for it? This simple indicator has proven effective and is scientifically recognized. But that pertains to economics. The research focuses on the appearance of cities and streetscapes, addressing the highly subjective phenomenon of how the spatial appropriateness (or “contextuality”) of a building is perceived. Could there also be a quantifiable “simple approximation value” for this? Hardly, but this article suggests and critically discusses one.

Two research questions are addressed: First, is such a loss in regional contextuality over time measurable by the suggested simple visual indicator? Second: If so, could the indicator be useful for assessing social sustainability?

Personal Narrative on This Research

New buildings, as results of an increasingly technically and economically determined planning process, often feel “soulless” and devoid of character. This perception is shared by laypeople and architects. But it wasn’t always like this. Since when do we perceive a loss of character (individuality, contextual appropriateness...) in the built environment? The 1960s? The 1970s?

As a researcher engaged in both sustainability quantification and cultural interpretation, I want to grasp and understand this phenomenon. This research started with an idea, inspired by the very simple “Big Mac Index” in economics. But the idea for a quantitative approach—capturing “contextuality” as “similarity” to what already exists in a region—could that really be a meaningful indicator of the phenomenon? Surely, only in strictly limited ways. But there are also see a connection to (social) sustainability, with its inherent demands for quantification.

The Social Sustainability Context

Urban planning and planning policies address functional aspects and the *appearance* of cities improving “urban quality” (Vanegas et al., 2010; Parfect & Power, 2014). Regulations concerning monument and ensemble protection, development plans, and land-use planning are among the most important instruments. Sustainability and the climate balance of urban functions are becoming central issues (Wheeler, 2016). The sustainability qualities of buildings and architecture are significant in this context. The livability and quality of life in a city in the age of rising temperatures and water shortages in many regions depend largely on its building stock.

In addition to planning methods, sustainability requirements derived from building codes, building-related life cycle assessments (LCA), or certifiers’ criteria play an increasing role. All this contributes to a significant increase in the complexity of creating sustainable cities. In addition to ecological life cycle assessments (LCA), social life cycle assessments (sLCA) are also conducted. The method has been internationally standardized by ISO

14075:2024. (ISO, 2024). Social LCA here is defined as “compilation and assessment of the socially relevant inputs and outputs and the potential social impacts of a product system throughout its life cycle”. It must be related to a so called functional unit, as square meters of a building e. g. As social impact, “aspects relating to human well-being of interested parties” are mentioned in a very wide manner. Unlike standard LCA, qualitative data are accepted here beside quantitative. Since this industry standard is still new, certain qualitative dimensions remain underdeveloped. Aspects of architectural identity are not explicitly addressed, as the standard describes a general method applicable to all industrial and economic activities. Aesthetics are not directly addressed, as factors like labor conditions, human rights, community impacts, health and safety are focused. But in the given framework of governance and cultural heritage, architectural identities can be considered indirectly. For example, “access to immaterial resources” and the “protection of regional identities” may be reflected through governance measures like stakeholder participation, which ISO 14075 explicitly mentions as beneficial.

In such a framework, quantification gains importance. Aesthetics can be methodologically integrated. Social sustainability as mentioned in the academic literature includes criteria such as the quality of stay in neighborhoods, neighborhood conservation, and acceptance of urban design (Allam et al., 2024). This essay proposes a way to reduce the complexity of sustainable architectural (urban) planning in light of these circumstances.

Green Building and City Planning and the Need for KPIs

Quantification might be useful as both, a planning “tool” and a rating “instrument”. A simple “visual proxy” for assessing the site-specific coherence and appropriateness (contextuality) of buildings is introduced and tested here, derived from visual comparisons of buildings. It has been designed to be very easy to calculate (see The BSI Indicator).

This attempt comes at a time when AI is becoming relevant in many areas of urban planning (Jiang et al., 2025). Other visual methods analyze urban streetscape attributes for planning and research. For example, computer vision techniques analyze urban streetscapes by processing geo-tagged street view images to extract detailed data on greenery, pavement materials, building facades, and urban furniture for urban researchers and planners—but their utility remains open (Liu & Sevtsuk, 2024). Personal reactions, so-called “emotional landscapes” or “emotional maps”, have been created as indicators of human-building (architecture) interaction (Meenar et al., 2025).

Not only sustainability ratings rely on quantifiable, comparable values. Construction companies and other stakeholders require measurable key performance indicators (KPIs) to assess sustainability goals (Drousa

et al., 2023; Saradara et al., 2024). Durability – linked to perceived adequacy (Bergmeister & Taferner, 2023) – as well as the social qualities of “green buildings” are significant factors. Second, AI-based research requires purely visual criteria for comparison. Third, rating methods could serve as additional tools for professional agents, such as building authorities, in their decision-making processes.

Within this framework, simple and easy-to-understand tools like the BSI can serve as a communicative aid for architects. They can be seen as a form of quantitative storytelling—simplifying a complex phenomenon of perception into straightforward comparative data. Within the Green Building framework, where energy and cost efficiency dominate construction priorities, the role of atmospherically sensitive, critical architecture is increasingly sidelined. Emotional arguments are undermined (Pallasmaa, 2014; Grossarth, 2025). However, if atmospheric perception is as complex as it appears – and easily ignored in decision making as “merely subjective” –, a purely efficiency-driven approach is insufficient. A more contextually appropriate architecture could also strengthen environmental concerns. This link is particularly evident in the preservation value and, consequently, the longevity of buildings – factors crucial to sustainability and life cycle assessments in the construction industry.

This study proposes a very simple – and admittedly too simple – method for quantifying architectural contextuality using AI-based visual comparisons. It might offer a quantifiable ‘proxy’ for a complex personal judgment that is based on emotional reactions, experience, culture and knowledge. The aim is to give the atmospheric and identity-forming qualities of architecture a “voice” within technically and economically dominated decision-making environments — one that can be recognized and understood even in those contexts.

BEYOND THE QUANTIFIABLE: PERCEPTUAL PHENOMENA OF URBAN “CONTEXTUAL ADEQUACY”

But how useful are image-based data-driven methods in adequately addressing complex, subjective and highly knowledge dependent phenomena such as judgments about appropriateness or similarity, coherence, or architectural quality?

Contextual Suitability is a big issue in architectural academics and urban planning practice (Vukmirović et al., 2015; van der Linden, 2021; Al-Hammadi & Grchev, 2023). On what terms can a building be appraised as “adequate” or “suitable” for its environment? Such a judgment is highly personal and subjective. Senses, feelings and experiences play key roles (Pallasmaa, 2024), but it is not purely subjective. The experience of “suitability” of architecture is intersubjectively

sharable, as many results of empirical aesthetics show (Jacobsen, 2006; Jacobsen & Beudt, 2017; Vartanian et al., 2013). Many factors play a role, including proportions, colors, materials, and style. However, even (radical) changes in styles and patterns can be perceived as adequate, while others are dismissed as “eyesores” (German: *Bausünden*). In professional contexts, such judgments are made by architectural juries, where senses, experience, knowledge, and underlying narratives shape the decision-making process. A sense of adequacy or suitability (*Angemessenheit*) is often described as an affective intuition – essential not only in architecture but also in other fields such as even case law (Landweer, 2020). In this sense, feelings and sentiments play a crucial role. Wouldn't any attempt to make such a phenomenon measurable be foolish? Maybe – but even a “foolish” indicator might address underrepresented interests of aesthetics in similiary “foolish” environments. This is further discussed in this article later.

First, what exactly does the term contextuality describe? The contextual suitability of buildings within their environment has been discussed as a key quality feature of architecture for decades (Brolin, 1980), although this perspective appears to be fading into oblivion (Komez Daglioglu, 2015). Recent research, which includes quantitative and qualitative content analyses of academic publications on contextual architecture, has identified two main fields of interest: architecture in historic urban contexts and sustainable buildings (Yücel & Arabacioglu, 2023). Contextuality has been considered in physical, social, cultural, and local terms. Context matters not only for surrounding buildings but also for infrastructure and landscapes (Schmandt, 1999).

Contextual suitability is closely linked to the concept of atmospheres. Both are identifiable through personal perception and are hardly measurable. Locally working architects—especially those in heritage conservation—describe their profession as being sensitive to specific local craft traditions, the history of individual buildings, and the atmospheres they evoke like shown in field studies with house owners (Yarrow, 2019). Architectural atmospheres have been described in phenomenology as an in-between phenomenon that emerges from a given place, its spatial context, and the sensory impressions of the observer (Böhme et al., 2014). The perception of these atmospheres is, to a lesser extent, cognitive and more strongly “embodied” (Fuchs, 2017).

The atmospheric and thus identity-related value of contextuality applies not only to neighboring buildings but also to the broader area, even extending to the city as a whole. Relevant categories include building materials, colors, architectural styles, window shapes, doorway arches, roof forms, and the specific history of a building in terms of its usage and construction evolution. While architecture situates its designs within historical contexts, it also evolves

them further. Stylistic inconsistencies and deliberate breaks with building traditions have long been part of modern architectural expression. By contrast, industrial housing construction in rapidly expanding cities is often characterized as dreary, monotonous, or part of a “cool technopolis” (Sennett, 2018). The new construction of office and multi-story residential buildings is frequently perceived as arbitrary—suggesting that such structures could exist anywhere in the world. This phenomenon is particularly evident in industrialized countries, where mass-produced building materials are widely available at low cost and where construction is heavily influenced by standardization and legal regulations. These regulations may pertain, for example, to fire safety or energy efficiency requirements for facades. As an unintended result, architectural qualities such as the situational appropriateness of a building are often lost.

THE BSI INDICATOR

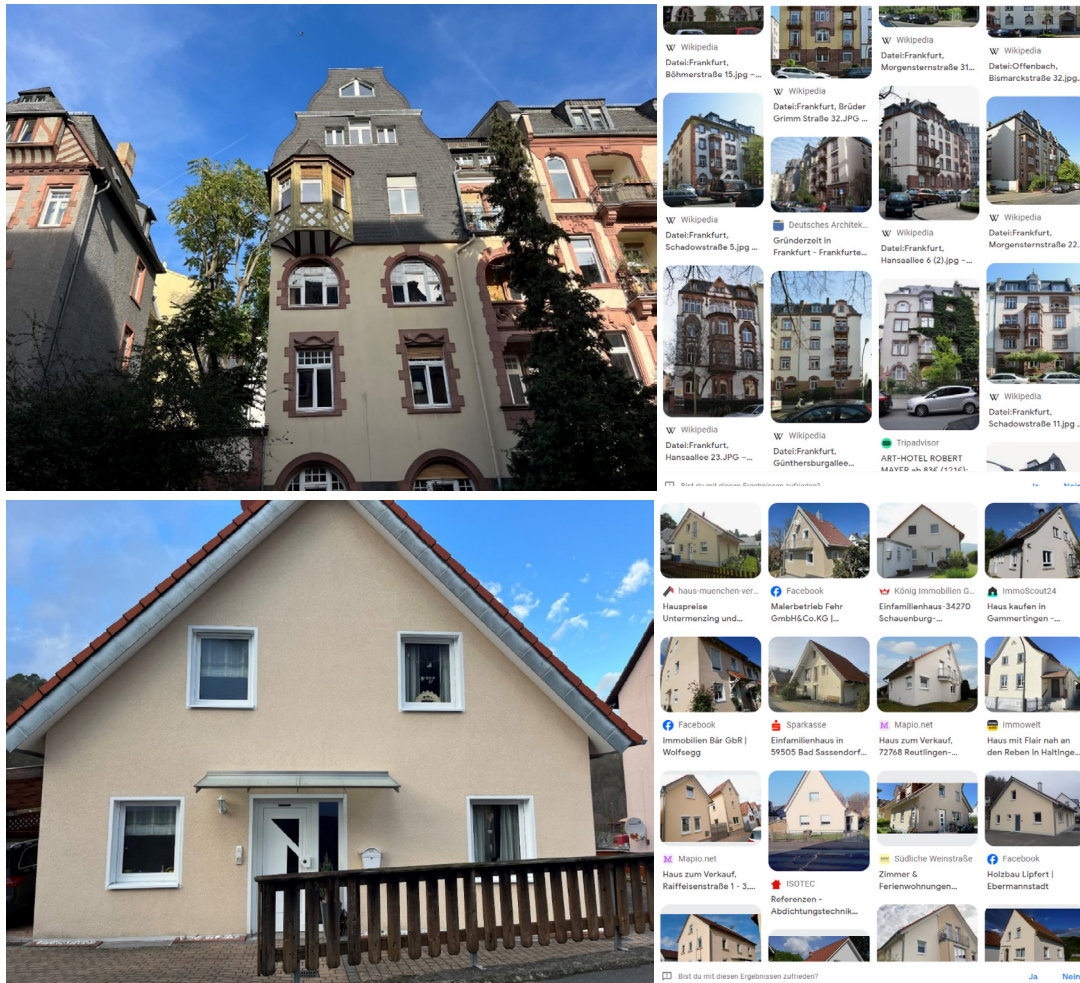
The indicator is called “BSI”, the “Building Similarity Indicator”. BSI is modeled as follows:

It is suggested to simply paste a photo of a building into “Google Lens” (former *Google Reverse Image Search*) and calculate an average value based on the distances of the search results. As examples, visually similar results for a historical building and a “modern” commercial single-family house are shown here (Figure 1a).

The following specifications were established: The first 10 search results were located. If the reverse image search identified the exact same building, the result was ignored, as only comparisons between different buildings were considered meaningful. The next closest matches were then analyzed. In some cases, localization was unclear. Stock photos without a specified location were ignored. The handling of construction companies' websites, which showcase examples of their work without clear localization, remains a matter of debate. Generally, results were included if the construction companies operated regionally, while those from large national companies were excluded. In the case of regional firms, the location of their headquarters was used for index calculation.

Google Lens searches for “visual matches”. The first 10 search results were quantified by measuring the distance between Point A, the location where the initial image was taken, and Point B, the location where the building visible in the search result is located. If a search result shows the building from the initial image or no building at all, the search result is skipped, and the next one is taken. This process continues until 10 distances could be measured. As mentioned before, buildings that are photographed too often, such as the Eiffel Tower, are excluded from the analysis, because it is very rare to find anything other than this exact building in the search

a



b

BSI Examples

Konstanz, Germany
Public Building

BSI 135

Strasbourg, France
Residential

BSI 32

Sonsonate, El Salvador
Residential

BSI 384

Panchimalco, El Salvador
Residential

BSI 224

Ravensburg, Germany
Residential

BSI 306

Sterzing, Italy
Residential

BSI 573

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BSI 1

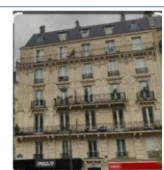


Figure 1. (a) Similar results for a historical building and a "modern" commercial single-family house. (b) Some of the BSI value examples.

results. If the search result shows a prefabricated house, the location of the prefabricated house company is used. If the result refers to a social media page, an attempt is made to find information about the location of the building there; otherwise, the location of the recipient is used (in our case, usually a craft business or construction company).

Using the ten distance values between the studied building and the search results, an average distance was calculated. To give statistical weight to buildings with many visually similar counterparts located within a relatively close range (under 100 km), some datasets were mathematically adjusted. The index value is based on the number of distance values below 100 km. If 0–2 of the ten distances were below 100 km, the index value equals the unadjusted average of all ten distances. If 3–5 distances were below 100 km, the average was reduced by one-third; if more than six distances were below 100 km, the average was reduced by half to determine the final index value.

BUILDINGS' BSIS: SOME EXAMPLES

Some examples for house images and their BSI values are listed in Figure 1b. One can, for example, see that the BSI does not increase with more recent construction years in any case. A residential building in East Berlin, for instance, has a low BSI value of 86. The typical GDR prefabricated slab building (1950s–1970s) is modern, yet regionally specific as BSI indicates. It's a striking irony: the absence of regional adaptation was a deliberate choice by GDR architects. While the same models were deployed across the GDR—making them regionally specific to socialist Eastern Europe—they were not locally adapted in architectural terms.

Another example shows accuracy of the BSI: The Parisian architectural style of the 19th century, with its cream-colored limestone and characteristic balconies, is highly specific and shows the lowest value, with a BSI of 1. A small townhouse in Alsace, France, is also strongly rooted in its regional context and ranks at BSI=32. This historic building likely dates from the late 19th or early 20th century and features a steep, multi-angled hipped roof, arched windows, and a red plaster façade, as typical of *Heimatstil* with *Jugendstil* influences, common in southern Germany or Alsace.

A post-war modernist building in Konstanz, Germany, shows numerous matches in the region—southern Germany—where floating window bands, the use of brick in the façade, and the flat roof are typical. This five-story building, likely from the 1950s or 1960s, is typical for West German postwar modernism in administrative or educational buildings. A modern exposed concrete villa, by contrast, shows little regional specificity; its value exceeds 300. Very high BSI values—and thus very low regional appropriateness—are seen in a multi-storey white-plastered

building in Sterzing, Italy (BSI=573) – a solid, typical worker housing from the early 20th century in the broader alpine region – and in El Salvador (BSI=384), where similar climate-adapted styles —designed for cross-ventilation, sun protection, and outdoor living – appear in many Central American holiday home developments.

EMPIRICAL RESULTS

As some aspects on the “Google Lens” tool and the exact data collection procedure are described in the Appendix, this section presents the data characteristics and identifies statistical patterns.

Descriptive Statistics

The “BSI indicator” can accurately be interpreted as follows:

The higher the indicator value, the greater the spatial dispersion of the ten most visually similar comparison buildings. (*formal definition*)

Or, more freely interpreted:

The higher the indicator value for a building, the lower its similarity to other local buildings based on visual criteria and publicly available data on the internet. (*semantic interpretation*)

What do the data reveal? Are there any notable patterns in the statistical distribution? Yes, there are (Figure 2).

Age

The index value consistently increases with the building age categories. Newer buildings, with estimated construction years from 2011 onward, exhibit the highest index values. This can be seen as evidence of an international and national standardization of architectural styles, driven by the industrialization of building materials, the professionalization of project planning, and possibly also the harmonization of sustainability and construction standards, such as ISO norms. Thus, research question 1 (“Is such a loss in regional contextuality over time measurable by the suggested simple visual indicator?”) can clearly be answered with “yes”.

Country

Looking at the country-level distribution, different patterns emerge. Among the countries with larger datasets, the United Kingdom, Denmark, Czechia, Switzerland and France show lower index values. This can be interpreted as an overall greater local appropriateness of construction across architectural periods and building types. In the case of the United Kingdom, for example, this pattern aligns with findings that self-building or craft-based renovation is more common, while commercially organized new construction plays a lesser role. It is possible that different heritage protection standards also play a role, though

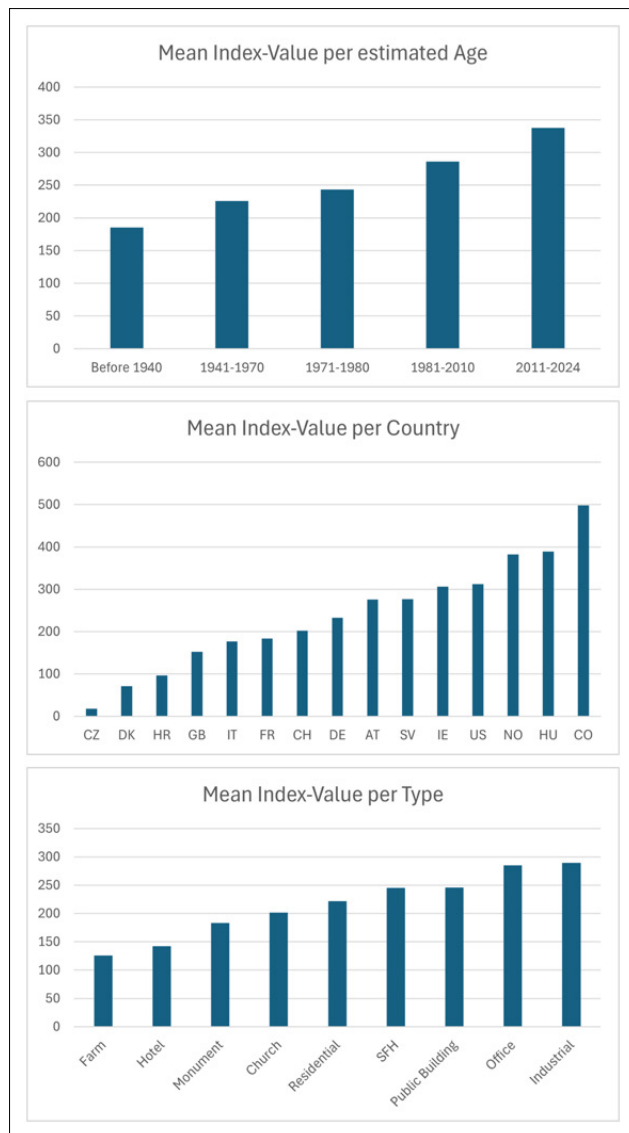


Figure 2. Descriptive statistics.

this remains speculative and would require further investigation.

Countries with particularly high index values include Austria, Germany, Hungary, Slovenia and Norway, as well as Colombia as an "outlier". One possible explanation for this could be a broader prevalence of industrially standardized building types and architectural styles.

Building Types

Differences also emerge regarding building types. Monumental buildings and agricultural structures exhibit greater local appropriateness compared to the overall average index value. Residential buildings fall into a middle range, while office and industrial buildings show the highest spatial dispersions of the ten most visually similar comparison buildings.

Remarks on Data Availability

Some aspects must be mentioned critically. In addition to statistical limitations of the explanatory regression models, there are also content-related limitations — this concerns, for example, the sources that "feed" Google Lens. Distortions are likely in this context. Sources from tourism and real estate sectors are often overrepresented in image archives, especially in regions with high tourism activity and extensive construction and real estate transactions. Representative and historically significant buildings are frequently photographed and can be accurately recognized by AI. If a region has little tourist appeal, there are, for example, fewer photos available as reference points. It is unclear what consequences this has for the explanatory power of the BSI. However, given the enormous flood of images on social media and the internet, it can be assumed that the data basis in industrialized countries is already very large and widespread by the mid-2020s. Therefore, the BSI is not significantly affected on the number of available comparison photos.

Further Examples of Intuitively (Non-) Valid BSI Indications

A historic urban villa in Vienna, with a mansard roof, Art Nouveau elements, and ornate façade detailing, might be considered highly place-specific. But the BSI value of 454 is high, as most visual matches are located in Munich (Figure 3). This could be due to the frequent use of yellow façade color in Munich. Here, the influence of color is likely overemphasized by the BSI. By contrast, a BSI of 1 for a grand corner building from the late 19th-century Viennese Gründerzeit period is intuitively convincing.

A Vienna residential building with BSI=693 represents contemporary minimalist architecture that prioritizes abstraction over regional references or contextual integration. Likewise, a BSI of 904 for an urban residential building with an angular, fragmented form, striped façade, and narrow balconies—typical of globalized contemporary architecture that emphasizes visual complexity over regional ties—also seems justified.

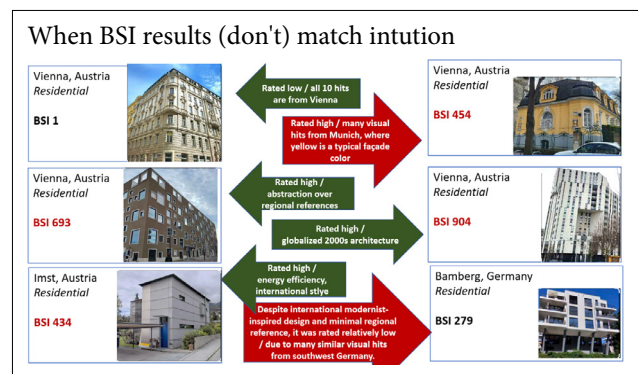


Figure 3. Visual matches that are located in Munich.

Regression Analysis and Interpretation

How about causality as statistically demonstrable? A simple statistical regression is used to examine which factors significantly influence the BSI value. However, since all explanatory variables—building type, construction age, and country—are binary-coded, the explanatory power of the results is limited. This section provides the rationale and discusses these limitations.

While different statistical distributions do not inherently indicate causality in terms of an explanatory power of “age”, “country” or “type” for the BSI index value, an OLS regression models relationships between variables, which may be interpreted causally under certain assumptions (Wooldridge, 2016). In multivariate regression analyses, multiple explanatory variables are related to a dependent variable. We have included all binary-coded variables in an OLS model to explain the similarity indicator value (problems linked to this model are discussed later). The regression can be represented as follows:

$$\text{BSI index} = \alpha + \beta_1 \text{Type1} + \beta_2 \text{Type2} + \dots + \beta_n \text{Type}_n + \gamma_1 \text{Age1} + \gamma_2 \text{Age2} + \dots + \gamma_n \text{Age}_n + \partial_1 \text{Country1} + \partial_2 \text{Country2} + \dots + \partial_n \text{Country}_n,$$

where *BSI index* is the building similarity index, α is the intercept, β_n are the OLS regression coefficients for n building Types, γ_n for building age classes, ∂_n for countries, and where all explaining variables are binary coded.

The model must be interpreted with very great caution due to more than one reason. If there are interactions between building type, age and country that are not explicitly modeled, the estimates might be biased or incomplete (see also discussion). The overall explanatory power of the multivariate model is relatively low (Figure 4). The residual standard error is 165.3, which represents the average deviation of the observed values from the predicted values. A lower value would indicate a better model fit. The R^2 coefficient of determination is 0.1934, meaning that only 19.34% of the variation in the dependent variable is explained by this model. R^2 is relatively low what suggests that important explanatory variables may be missing or that the data exhibit high variability. The adjusted R^2 value is 0.1188, which accounts for the number of predictors. Since this value is lower than R^2 , it indicates that some variables may not significantly improve the model. Overall, the model is statistically significant, meaning that at least one independent variable has an explanatory influence on the dependent variable (F-statistic: 2.592, $p=5.017\text{e-}05$). The intercept value (220.846, $p=0.0769$) suggests that if all explanatory variables were set to zero, the dependent variable would be approximately 220.8. However, this value is not highly significant ($p>0.05$) but is close to the threshold.

Residuals:				
Min	1Q	Median	3Q	Max
-320.05	-112.33	-41.61	95.70	473.29
Coefficients: (2 not defined because of singularities)				
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	220.846	124.397	1.775	0.076885 .
Type_SFH	-54.811	55.814	-0.982	0.326895 .
Type_Farm	-114.980	79.727	-1.442	0.150324
Type_Residential	-69.763	53.743	-1.298	0.195283
Type_Industrial	37.810	72.073	0.525	0.600251
Type_Office	-65.895	92.454	-0.713	0.476579
Type_Public_Building	-62.985	60.116	-1.048	0.295625
Type_Monument	9.471	67.764	0.140	0.888942
Type_Hotel	-151.385	69.929	-2.165	0.031209 *
Type_Church	NA	NA	NA	NA
Age_Before_1940	52.628	55.890	0.942	0.347155
Age_1941_1970	99.978	58.262	1.716	0.087220 .
Age_1971_1980	120.740	61.528	1.962	0.050669 .
Age_1981_2010	164.140	61.065	2.688	0.007601 **
Age_2011_2024	206.188	59.957	3.439	0.000669 ***
Country_GB	-119.696	109.796	-1.090	0.276537
Country_FR	-30.290	113.740	-0.266	0.790186
Country_AT	7.782	101.466	0.077	0.938916
Country_CH	-78.782	112.395	-0.701	0.483901
Country_DE	-20.128	100.130	-0.201	0.840826
Country_CO	125.777	193.458	0.650	0.516106
Country_CZ	-51.461	201.681	-0.255	0.798778
Country_DK	-180.061	156.240	-1.152	0.250075
Country_HR	-179.785	118.440	-1.518	0.130113
Country_HU	131.161	197.490	0.664	0.507123
Country_IE	54.238	111.063	0.488	0.625664
Country_IT	-77.868	102.366	-0.761	0.447462
Country_NO	91.144	153.929	0.592	0.554230
Country_SV	-26.804	136.463	-0.196	0.844420
Country_US	NA	NA	NA	NA

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 165.3 on 292 degrees of freedom				
Multiple R-squared: 0.1934, Adjusted R-squared: 0.1188				
F-statistic: 2.592 on 27 and 292 DF, p-value: 5.017e-05				

Figure 4. OLS regression.

The strongest and most significant relationships are observed in relation to the construction years of the buildings: The newer a building, the higher the value of the BSI. This - in line with the results of the descriptive statistic - suggests an increasing standardization or homogenization of modern buildings. Buildings from the most recent period, with estimated construction years from 2011 onward, show the highest positive and highly significant effect on BSI (206.188, $p=0.000669$, $p<0.001$). Buildings estimated to have been constructed between 1981 and 2010 exhibit a strong positive and significant effect on BSI (184.140, $p=0.0076$). Buildings from the 1971–1980 period also show a positive but only marginally significant effect. All older building age classes have positive but no longer significant effects, with those built between 1941 and 1970 coming close to the threshold for statistical significance. The significance levels remain comparable even when the explanatory variable classes Age and Country are omitted, which also helps reduce multicollinearity issues (see Appendix).

On the other hand, the only statistically significant explanatory variable among building types is the hotel category. Single-family houses show a negative but not significant effect (-54.811, $p=0.327$), while farms also exhibit a negative but not significant effect (-114.980, $p=0.150$). Similarly, residential buildings have a negative but not significant effect (-69.763, $p=0.195$). Industrial

buildings, on the other hand, show a positive but not significant effect on BSI (37.810, $p=0.600$). Office buildings (-65.895, $p=0.477$) and public buildings (-62.985, $p=0.296$) also display negative but not significant effects. Heritage buildings have only a very small and non-significant effect (9.471, $p=0.889$). It is worth noting that the regression does not return values for churches (NA), which suggests that this category was excluded due to multicollinearity. Hotels, however, exhibit a significantly negative effect ($p<0.05$), meaning that these buildings have significantly lower values for the dependent variable (-151.385, $p=0.031$). In other words, if a building is classified as a hotel, its architecture is significantly more similar across all observations.

Also, the country comparison in the OLS model is not very informative. No country shows a highly significant deviation. However, there is a tendency for some countries with less standardized construction methods, such as Denmark and the United Kingdom, to have negative values.

A key issue affecting the overall model fit is likely the exclusive use of binary explanatory variables (Frazis & Löwenstein, 2003). A model with only binary predictors in many cases has the deficit that the coefficient only reflects the average difference between groups (e.g., houses in Germany versus all countries) and cannot truly be interpreted as a “causal” effect in the strict sense. Since all explanatory variables are binary, each coefficient represents the expected difference in the BSI index when the variable is 1 compared to the reference category (which is implicitly set to 0). However, this does not necessarily imply a causal effect unless endogeneity issues (e.g., omitted variables, selection bias) are addressed. In particular, the binary structure of the “explanatory” variables proves to be a methodological problem. An improved model with additional explanatory variables could help improve the model’s quality. A deeper analysis of construction years could reveal patterns explaining why newer buildings have higher index values. The non-significant country effects could be further investigated with additional data, e. g. regional.

Personal Reflection on This Work

The result is interesting: It conveys something meaningful. But actually, this isn’t primarily about the “BSI indicator value” itself. It’s more about the combination with the image results from Google – and what they reveal. In combination, BSI value and interpretation yield a “quantitative storytelling” about similarity and adequacy. What is needed now is a follow-up study asking: Do the buildings with a low BSI score correspond more closely to your aesthetic preferences than the others? Because the original idea was to use similarity to geographically nearby buildings as a kind of proxy for appropriateness – and ultimately, that’s about aesthetic perception.

CONCLUSION

In the 2020s, construction experts often build in ways that no longer fit the surrounding place. This article addressed this as a serious concern. While the method may seem somewhat playful, also the suggested approach has its technocratic side. Quantifying contextual adequacy – seriously? The aim, however, was to enable a quantification of the phenomenon of architectural appropriateness in the professional areas, where quantification is needed. This research did this in order to allow the usage of BSI for a subsequent, meaning-generating interpretation.

With the BSI, a simple similarity indicator was proposed and tested using 320 data sets. It reflects similarity to architectural styles based on the geographical proximity of a building. This was proposed as an approximation of the more complex phenomenon of appropriateness in architecture.

The BSI index has significant weaknesses. What does such an indicator based on geographical proximity not represent?

- It defines geographic contextuality rigidly in terms of distance in kilometers. But in post-postmodern times and cities, given a high variety and architecturally “salad bowl” character of streets, neighbourhoods and city quarters, BSI can hardly be seen as an appropriate single measure. What in a specific street or backyard situation might be seen as “appropriate” by architectural experts or by majorities of laypeople, might be not in the next. In such urbanized contexts, the BSI easily fails.
- BSI is not suitable for evaluating exceptional architecture that does not aspire to regional similarity, but achieves a sense of appropriateness through stylistic ruptures, modernity, and breaking out of the expected framework.
- The indicator can strongly overemphasize a single aspect of similarity — such as a material or color (see sec. 4) — even when the “trained human eye” would still judge a building as highly appropriate to its local context.
- In other specific cases, the indicator can also fail significantly. For instance, there is a geographic boundary where traditional stone and half-timbered construction meet. Here, a comparison value like “500 km” tells us little—certainly, a half-timbered house is more “similar” to another half-timbered house 500 kilometers away than to a natural stone house just 10 kilometers away.
- The indicator also exhibits other distortions. The more widely a historical building style or material is geographically distributed, the more the BSI shows upward bias. The honey-colored sandstone of the British Cotswolds, for example, is a highly region-specific material—very low values are “naturally” to be expected here. In contrast, traditional Asian bamboo construction is spread over thousands of kilometers.

However, the indicator also shows strengths:

- It identifies and “acknowledged” highly complex weightings of forms, colors, materials, and façade elements in many cases.
- In many cases, the BSI does provide a reasonable indication of geographical contextuality. For mass housing or single-family homes, this criterion often aligns with the needs of the users on-site, though it is increasingly disregarded. For these areas, the BSI appears to be a not entirely pointless quantitative “tool” for supplementary evaluation, but a meaningfully interpretable representation of social values.
- In the case of individual projects or plans, the BSI is only meaningful when combined with a qualitative interpretation of the visual results. (Only in the case of large-scale comparisons, its value can carry significance on its own).

In summary, the BSI has some charm – but won’t heal the sufferings of socially unsustainable construction. The indicator was deliberately kept simple. It provides results that are intuitively understandable. The houses exhibit comprehensible similarities regarding facade materials, the number and placement of windows and doors, and the colors and shapes used. The BSI provides a certain statement about the appropriateness in terms of a visual overall impression.

Descriptive data of 320 datasets and statistical tests demonstrate that newer buildings are increasingly arbitrary

in their design. With regard to the first research question, this means that the BSI, as a quantifiable measure, reliably indicates regional contextuality based on diverse visual criteria (Figure 5). Furthermore, by linking contextuality to cultural values and the protection of cultural identities, the BSI could potentially be integrated into sustainability evaluations such as social life cycle assessment (sLCA). However, as a quantifiable indicator, it should also be viewed in that context as complementary to participatory approaches such as stakeholder dialogues, which may be more suitable for capturing personal experiences of contextuality and identity-related aspects of architecture.

In further research, the BSI:

- could be generated automatically or calculated using Artificial Intelligence (AI) tools, allowing for the analysis of even larger datasets.
- is also relevant for further cross-country comparisons or more precise analyses of construction years, particularly when based on actual rather than estimated building dates.
- could be tested against empirical studies on aesthetic perception to examine whether buildings with lower BSI scores are perceived as more appropriate—thus validating the indicator’s underlying hypothesis.
- should be further integrated into sLCA and other social sustainability assessment frameworks, with detailed methodological development.

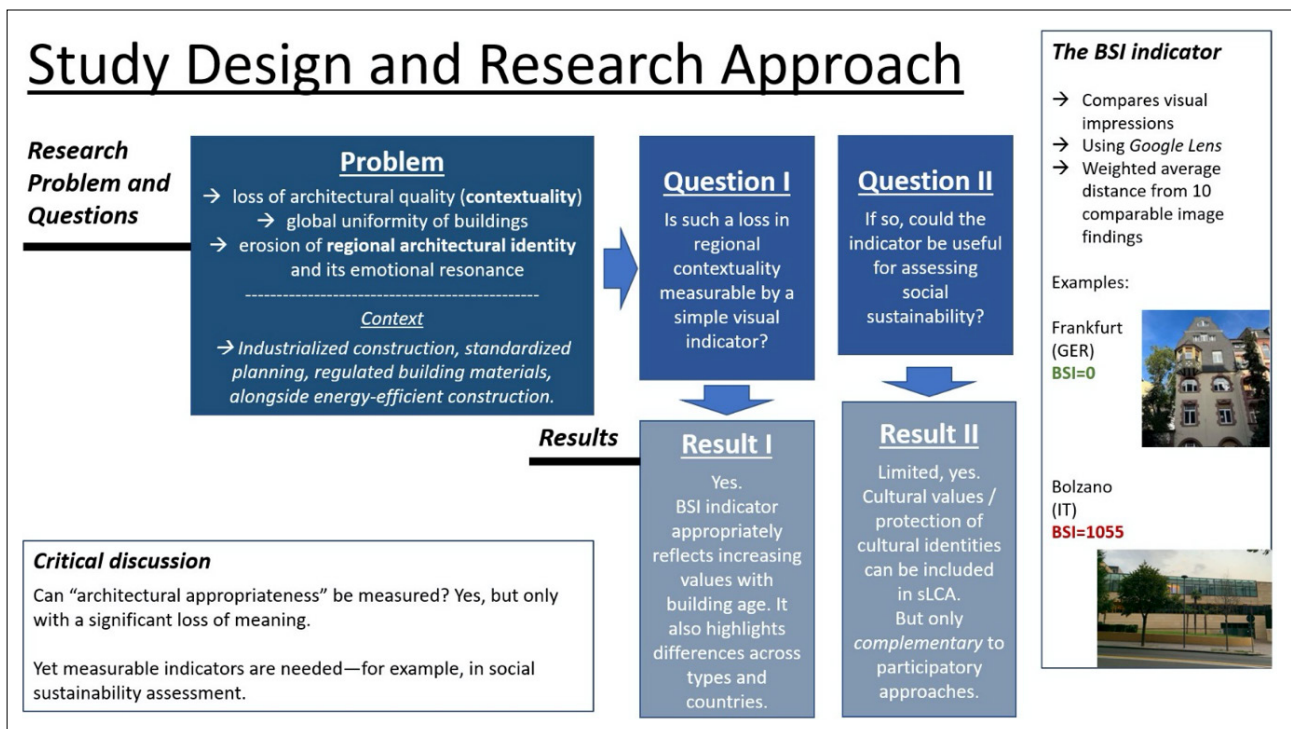


Figure 5. Approach of this study.

The true qualities of architecture surpass what can be expressed in numbers and metrics. The sense of appropriateness of a building to its location requires knowledge, a trained eye, and a multimodal perception of the surroundings. However, the attempt to measure the "immeasurable"—even if somewhat playful in intent—is not without interest. The results demonstrate high plausibility and primarily reflect the increasing arbitrariness of architecture throughout the 20th century. Ironically, a formal quantitative indicator – while largely simplifying an experimental phenomenon – could contribute to re-focus on the socio-material richness of buildings. Quantification is the language of industrial engineering. But social sustainability, as Lucius Burckhardt (2022) put it, means “minimal intervention” based on local awareness – and thus the preservation of regional anchors of identity.

Appendices: [https://jag.journalagent.com/megaron/abs/files/MEGARON-12316/MEGARON-12316 \(3\) MEGARON-12316 Appendices.pdf](https://jag.journalagent.com/megaron/abs/files/MEGARON-12316/MEGARON-12316 (3) MEGARON-12316 Appendices.pdf)

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REFERENCES

- Abel, C. (2012). *Architecture and identity*. Routledge. <https://doi.org/10.4324/9780080939018>
- Akarsu, M. Z., Gharehgozli, O., & Atal, V. (2024). Big Mac affordability and income inequality across the European Union. *Journal of Economic Studies*, 52(6), 1189–208. <https://doi.org/10.1108/JES-06-2024-0421>
- Al-Hammadi, N. A., & Grchev, K. (2023). Aspects of contextual architecture regarding traditional/contemporary architecture, physical/cultural and place identity: A systematic literature review. *Open House International*, 48(1), 119–40. <https://doi.org/10.1108/OHI-01-2022-0007>
- Allam, Z., Sharma, A., & Cheshmehzangi, A. (2024). Life in the city: Behavioural changes can drive urban sustainability goals. *Cities*, 151, 105163. <https://doi.org/10.1016/j.cities.2024.105163>
- Bergmeister, K., & Taferner, J. (2023). The beauty of simplicity and recyclability. In *International Symposium of the International Federation for Structural Concrete* (pp. 13–26). Springer. https://doi.org/10.1007/978-3-031-32519-9_2
- Bitirim, Y. (2022). Retrieval effectiveness of Google on reverse image search. *Journal of Imaging Science & Technology*, 66, 010505-1. <https://doi.org/10.2352/J.ImagingSci.Technol.2022.66.1.010505>
- Böhme, G., Borch, C., Eliasson, Ö., & Pallasmaa, J. (2014). *Architectural atmospheres: On the experience and politics of architecture*. Birkhäuser. <https://doi.org/10.1515/9783038211785>
- Brolin, B. C. (1980). *Architecture in context: Fitting new buildings with old*. Van Nostrand Reinhold.
- Burckhardt, L. (2022). *The minimal intervention*. Birkhäuser.
- Clements, K. W., & Si, J. (2017). Simplifying the Big Mac Index. *Journal of International Financial Management & Accounting*, 28(1), 86–99. <https://doi.org/10.1111/jifm.12058>
- Droutsas, K. G., Balaras, C. A., Dascalaki, E. G., Kontoyianidis, S., Moro, A., & Bazzan, E. (2023). Key performance indicators for sustainable Mediterranean buildings and cities. *IOP Conference Series: Earth and Environmental Science*, 1196(1), 012076. <https://doi.org/10.1088/1755-1315/1196/1/012076>
- Frazis, H., & Löwenstein, M. A. (2003). Estimating linear regressions with mismeasured, possibly endogenous, binary explanatory variables. *Journal of Econometrics*, 117(1), 151–78. [https://doi.org/10.1016/S0304-4076\(03\)00121-0](https://doi.org/10.1016/S0304-4076(03)00121-0)
- Fuchs, T. (2017). Embodiment – Verkörperung, Gefühl und Leibgedächtnis [Embodiment, feeling, and body memory]. *Psychoanalyse im Widerspruch*, 29(1), 9–28. <https://doi.org/10.30820/0941-5378-2017-1-9>
- Groat, L. N. (2024). Contextual compatibility in architecture. In *Environmental Perspectives* (pp. 215–32). Routledge. <https://doi.org/10.4324/9781003500582-17>
- Grossarth, J. (2025). *Bioeconomy of buildings: From resource flows to meanings*. Springer. <https://doi.org/10.1007/978-3-031-84014-2>
- ISO. (2024). *Principles and framework for social life cycle assessment*. ISO 14075:2024
- Jacobsen, T. (2006). Bridging the arts and sciences: A framework for the psychology of aesthetics. *Leonardo*, 39(2), 155–62. <https://doi.org/10.1162/leon.2006.39.2.155>
- Jacobsen, T., & Beudt, S. (2017). Stability and variability in aesthetic experience: A review. *Frontiers in Psychology*

- gy, 8, 143. <https://doi.org/10.3389/fpsyg.2017.00143>
- Jiang, H., Li, M., Witte, P., Geertman, S., & Pan, H. (2025). Urban chatter: Exploring the potential of ChatGPT-like and generative AI in enhancing planning support. *Cities*, 158, 105701. <https://doi.org/10.1016/j.cities.2025.105701>
- Komez Daglioglu, E. (2015). The context debate: An archaeology. *Architectural Theory Review*, 20(2), 266–79. <https://doi.org/10.1080/13264826.2016.1170058>
- Landweer, H. (2020). Warum Normen allein nicht reichen. Sinn für Angemessenheit und Rechtsgefühl in rechtsästhetischer Perspektive [Why standards alone are not enough. A sense of appropriateness and legal feeling from a legal aesthetic perspective]. In *Rechtsästhetik in rechtsphilosophischer Absicht* [Legal aesthetics with philosophical intention] (pp. 61–84). Nomos Verlagsgesellschaft. <https://doi.org/10.5771/9783748908784-61>
- Liu, L., & Sevtsuk, A. (2024). Clarity or confusion: A review of computer vision street attributes in urban studies and planning. *Cities*, 150, 105022. <https://doi.org/10.1016/j.cities.2024.105022>
- Meenar, M., Pánek, J., Kitson, J., & York, A. (2025). Mapping the emotional landscapes of parks in post-industrial communities enduring environmental injustices: Potential implications for biophilic city planning. *Cities*, 158, 105692. <https://doi.org/10.1016/j.cities.2024.105692>
- Ong, L. (2003). *The Big Mac Index: Applications of purchasing power parity*. Springer. <https://doi.org/10.1057/9780230512412>
- Pallasmaa, J. (2014). Space, place and atmosphere: Emotion and peripheral perception in architectural experience. In Borch, C., ed. *Architectural Atmospheres: On the Experience and Politics of Architecture*, Birkhäuser, 2014, pp. 18–41. <https://doi.org/10.1515/9783038211785.18>
- Pallasmaa, J. (2024). *The eyes of the skin: Architecture and the senses*. John Wiley & Sons. <https://doi.org/10.1002/9781394200702>
- Parfect, M., & Power, G. (2014). *Planning for urban quality: Urban design in towns and cities*. Routledge. <https://doi.org/10.4324/9780203754467>
- Saradara, S. M., Lara, J. C., Swarnakar, V., Rauf, A., Qureshi, R., Fadel, M., & Khalfan, M. M. (2024). Construction and demolition waste management in the United Arab Emirates through the 3R principle. *Engineering, Construction and Architectural Management*, 31(13), 430–54. <https://doi.org/10.1108/ECAM-06-2024-0810>
- Schmandt, M. J. (1999). The importance of history and context in the postmodern urban landscape. *Landscape J*, 18(2), 157–65. <https://doi.org/10.3368/lj.18.2.157>
- Schooper, T. (2016). *Ein Haus: Werk-Ding-Zeug?: Gespräche mit Gion A. Caminada, Hermann Czech, Tom Emerson, Hans Kollhoff, Valerio Olgiati* [A House: Work-Thing-Tool?: Conversations with Gion A. Caminada, Hermann Czech, Tom Emerson, Hans Kollhoff, Valerio Olgiati]. Passagen Verlag.
- Sennett, R. (2018). *Building and dwelling: Ethics for the city*. Farrar, Straus and Giroux.
- Van der Linden, M. (2021). *Architecture: Changing spatial transitions between context, construction and human activities*. Springer Nature. <https://doi.org/10.1007/978-981-33-4658-1>
- Vanegas, C. A., Aliaga, D. G., Wonka, P., Müller, P., Waddell, P., & Watson, B. (2010). Modelling the appearance and behaviour of urban spaces. *Computer Graphics Forum*, 29(1), 25–42. <https://doi.org/10.1111/j.1467-8659.2009.01535.x>
- Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., Nadal, M., Rostrup, N., & Skov, M. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences of the United States of America*, 110(Suppl. 2), 10446–53. <https://doi.org/10.1073/pnas.1301227110>
- Vukmirović, M., Vaništa Lazarević, E., & Marić, J. (2015). A new tool for assessment of contextuality of architecture. In *REAL CORP 2015. Plan Together–Right Now–Overall. From Vision to Reality for Vibrant Cities and Regions: Proceedings of the 20th International Conference on Urban Planning, Regional Development and Information Society* (pp. 39–48). Schwechat: CORP-Competence Center of Urban and Regional Planning.
- Wheeler, S. M. (2016). Sustainability planning as paradigm change. *Urban Planning*, 1(3), 55–8. <https://doi.org/10.17645/up.v1i3.740>
- Wooldridge, J. M. (2016). *Introductory econometrics: A modern approach* (6th ed.). Cengage Learning.
- Yarrow, T. (2019). How conservation matters: Ethnographic explorations of historic building renovation. *Journal of Material Culture*, 24(1), 3–21. <https://doi.org/10.1177/1359183518769111>
- Yuan, S., & Wu, X. (2021). Deep learning for insider threat detection: Review, challenges and opportunities. *Computers & Security*, 104, 102221. <https://doi.org/10.1016/j.cose.2021.102221>
- Yücel, R. K., & Arabacıoğlu, F. P. (2023). “Context” knowledge in architecture: A systematic literature review. *Megaron*, 18(3), 366–86. <https://doi.org/10.14744/megaron.2023.81594>



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Article

The role of media in architectural studies: An analysis of research on newspapers and periodicals

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ABSTRACT

The purpose of this study is to examine, from a comprehensive standpoint, how architecture and printed mass media -such as newspapers and periodical- interact, as well as how these media shape architectural discourses and public opinion.

This study holistically examines the relationship between architecture and printed mass media (newspapers and periodicals). Systematic literature reviews evaluate the place of these tools in architectural research, their evolution over time, and their contributions. The study employs a mixed research methodology combining quantitative and qualitative methods. As a result of querying the Web of Science database with the keywords "Architecture," "Newspaper," "Journal," "Magazine," and "Mass Media," 127 articles were selected and analyzed with RStudio software.

In terms of publications, authors, journals, and countries, the research shows the structure, trends, and patterns of this field of study. The results draw attention to the role of newspapers and periodicals in shaping architectural public opinion. Moreover, architectural discourses disseminated through the media affect not only architectural designs but also social and ideological structures. The study provides significant findings on how architectural history is rewritten through the media.

This study presents a holistic analysis of this field by discussing the role of mass media in shaping research in the discipline of architecture. This comprehensive approach to the impact of media on architectural history and public opinion aims to reveal the existing knowledge gaps in the field.

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INTRODUCTION

Throughout history, the discipline of architecture has been undergoing a continuous process of evolution under the influence of social, cultural, and technological changes.

To understand this process of change and to analyze the development of architectural practices in detail, researchers examine the existing building stock and use various written sources. These written sources, which provide essential information in fields such as architectural history, theory,

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and criticism, play a critical role in understanding the broader context of the discipline. Archival documents, visual documents (maps, engravings, paintings, etc.), books on the subject, monographs, public-private records, and mass media are among the primary sources used in architectural research. This study aims to systematically analyze how printed mass communication tools, such as newspapers and magazines, are utilized in architectural research, thereby revealing the role of these sources in shaping architectural thought.

Architectural theory has evolved in tandem with transformations in media technologies throughout history; forms of expression, representation, and circulation have been redefined in response to the technical possibilities of each era. The origins of this relationship date back to the Ancient World, when Vitruvius's *De Architectura* systematically codified written architectural knowledge; this work not only conveyed technical information but also established the intellectual framework of architecture (Rykwert, 1980). With the invention of the printing press during the Renaissance, this knowledge could be reproduced and disseminated to broader audiences; the writings of authors such as Alberti and Serlio enhanced the public nature of theoretical thought, transforming architectural practice and education (Wittkower, 1998; Alberti, 1485/1988). In the 19th century, architectural theory and history became institutionalized as distinct disciplines within the academic sphere, and this distinction facilitated theoretical diversification, particularly through its connections with art history, aesthetics, and critical thinking (Mallgrave, 2005). In the 20th century, the proliferation of printed publications - especially magazines and manifestos - paved the way for theory to circulate globally; publications such as *Architectural Review* and *Oppositions* enabled architecture to be discussed not only as a professional field but also as an ideological and cultural one (Colomina, 2020; Ockman, 2000). McLuhan's (1962) statement that "the medium is the message" emphasizes that the media are not merely a channel of transmission but also a shaper of intellectual structures; this perspective reveals that the formal structures of architectural theory cannot be considered independent of media technologies. In this context, every transformation in media technologies has reproduced the representational forms and epistemological structure of architectural theory. Today, digital media, with its speed, interactivity, and participatory structure, has not only transformed the production and circulation forms of architectural theory but has also become a constitutive framework that determines the social experience, representation, and public space of contemporary architecture (Carpo, 2011; McQuire, 2009). The relationship between media and architecture

is not just about building things, but also about shaping, discussing, and rewriting intellectual practices in the digital world, demonstrating the importance of taking an interdisciplinary approach (Lindsay et al., 2025). Thus, architecture is no longer merely a physical production that is built; it has become an intellectual practice that is shaped, discussed, and rewritten in the digital environment. In this context, the role played by mass communication tools, such as newspapers and magazines, in the production, representation, and circulation of architectural thought within the social sphere is worthy of historical examination. The interaction between architectural theory and media technologies provides a basis for systematically examining the impact of print publications on architectural studies through bibliometric analysis. The bibliometric method employed in this study aims to reveal how architectural discourse in newspapers and magazines has historically evolved and which theoretical themes have emerged, utilizing quantitative data.

This study focuses on the use of newspapers and periodicals such as magazines, little magazines, and journals in architectural research. Mass media connect societies through a communication network, allowing people to obtain information about what is happening around them (Tokgöz, 1981). The publications are essential sources of information in architectural research due to their capacity to reflect the social dynamics, cultural trends, and technological innovations of specific periods (Arabacı, 2004; Başaran, 2010). They reflect current events, developments, and a particular period's social and cultural atmosphere.

Using newspapers and periodicals in architectural research allows researchers to better understand a particular period's social and cultural context. According to Colomina, the center of architectural production is no longer just the construction site but the site of various publications and events such as magazines, posters, and exhibitions. Colomina emphasizes that mass media often outlive buildings. This shows that the structures designed by architects retain their place in history and are constantly recreated with the help of mass media (Colomina, 2020). This shows that architecture is not only a physical entity but also a phenomenon that is constantly constructed in the media and social memory.

Newspapers and periodicals can be applied to various tasks when conducting architectural research. Those works are valuable resources for documenting and comprehending the historical background. These publications are good sources for understanding the ideas, practices, and projects related to architecture within a specific time. They are also helpful for researching public opinion and perception. (Sklaire & Gherardi, 2012; Lindsay & Sawyer,

2021). They are analyzed to understand what the public thinks about architectural projects and urban planning and the social impact of these projects. Bernard Cohen (2015), in his work "The Press and Foreign Policy," defines the idea of agenda-setting as follows: "It may not be successful much of the time in telling people what to think, but it is stunningly successful in telling its readers what to think about". Print outlets are used to understand the public perception and discussion of architectural projects (Franco & Ortiz, 2020; de Oliveira Capela & Ramirez-Marquez, 2019; Lyytimäki, 2014; Hayes, 2000).

Architectural criticism also frequently appears in newspapers and periodicals. These reviews provide a valuable reference for academic studies by reflecting professional perspectives on the design, function, and aesthetics of a building. Researchers and architects can also study periodical advertisements and promotions to understand how architectural styles and materials are marketed (Hornbeck, 1999). It provides important clues to the history of architecture and the use of materials. These publications are also used to promote innovative architectural projects and technologies (Alaily-Mattar et al., 2021). Therefore, they are essential for documenting innovative solutions and techniques of the period.

Cultural and social studies utilize newspapers and periodicals to examine the influence of cultural and social norms prevailing in a particular period or region on architecture. These publications provide valuable information for understanding the relationship between architecture and social dynamics (García Estévez et al., 2019). Finally, news reports on specific architectural projects, activities, events, or debates provide researchers with a detailed examination of particular cases or examples. Thus, they are essential primary and secondary sources in architectural research.

This study examines the place of the use of newspapers and periodicals in architectural studies in the scientific literature. It is limited to Web of Science (WoS) database articles. WoS is a comprehensive online database where academic and scientific publications are indexed, and citation analysis can be performed. Global researchers use the Web of Science extensively in almost every field of knowledge. An essential resource for researchers and academics, WoS includes scientific journals, conference proceedings, and other academic works in various disciplines (Li et al., 2018).

This study aims to determine how research trends in architecture using newspapers and periodicals from mass media have evolved and diversified in the literature. In this direction, qualitative and quantitative analyses were conducted on bibliographic data. Quantitative studies consist of metric analyses, and qualitative studies consist of content analyses.

METHODOLOGY

Mixed-Method Systematic Research Approach

This study aims to analyze the relationships between architecture comprehensively and printed mass media (newspapers and periodicals) from a holistic perspective. Systematic literature reviews are comprehensive investigations based on scientific methods to make sense of large information bodies and answer specific research questions. By evaluating the existing literature in depth, these reviews reveal uncertainties and inconsistencies in the state of knowledge, identify areas where further research is needed, and provide guidance for future studies. Literature reviews combine the findings of different studies in a field, analyzing the variations between these findings and providing a clearer overall picture. It comprehensively assesses existing knowledge and methodological recommendations for future research. Systematic reviews aim to summarize the evidence in a subject area from a holistic perspective, guide research efforts more effectively, and contribute to developing new methods. Accordingly, the research questions are as follows:

- What is the place of mass media (newspapers and periodicals) in architectural research?
- How has using newspapers and periodicals in architectural research changed over time?
- What are the contributions of newspapers and periodicals as research materials in architectural research?
- How might the future role of mass media (newspapers and periodicals) evolve in architecture?
- Are there regional differences in the use of mass media? If so, how are these differences reflected in architectural research?

Data Collection: Selection of Database and Review Queries

The data collection process was initiated on August 23, 2024, using the Web of Science (WoS) database. Among the reasons for choosing WoS are that it provides comprehensive content from different disciplines, offers a wide variety of journals, covers high-impact journals, makes it easy to search, provides quality analysis content, and is widely used (Li et al., 2018). In addition, the fact that WoS defines Architecture as a field of science makes it easier to access relevant articles and provides a significant advantage to researchers in data cleaning/screening steps.

In this study, a targeted literature search strategy was employed to examine publications within the field of architecture. The Web of Science database query was performed in the "architecture" category in this database. The search was conducted within the abstract field only, using the following query, with no restrictions on

publication date: Architecture AND (newspaper OR journal OR magazine OR “mass media”).

To ensure relevance and scholarly quality, only articles indexed in the Arts & Humanities Citation Index (A&HCI), Social Sciences Citation Index (SSCI), Emerging Sources Citation Index (ESCI), and Science Citation Index Expanded (SCI-EXPANDED) were included. Furthermore, the scope was limited to English and Turkish language publications, as well as the article document type.

Although no temporal constraints were applied during the search, the resulting dataset predominantly covers the period between 2003 and 2024, reflecting the indexing span of relevant publications in WoS that meet the search criteria.

After collecting 193 articles, precise inclusion and exclusion criteria were established to efficiently filter and select only those relevant to the research topic. After importing every article into Mendeley, 4 duplicate entries were found and eliminated. The remaining articles were listed in Excel, and the full text was carefully reviewed. During this process, articles not directly related to the research topic were excluded, removing 56. Additionally, 6 articles were excluded due to inaccessible full texts. Consequently, 127 articles were selected for inclusion in the study (Figure 1).

Selected articles were saved in plain text format and analyzed in RStudio. The authors identified the newspapers and periodicals analyzed by these articles and saved their names in an Excel file. The bibliographic metadata analysis assessed the completeness of the dataset, comprising

127 documents. Most categories were rated “Excellent,” although some showed deficiency rates (Table 1). Significant deficiencies were found in the Keywords (40.94% missing) and Keywords Plus (88.19% missing) categories, rated as “Poor” and “Critical,” respectively (Table 1). Due to these metadata limitations, analyzing bigrams from article abstracts was considered a more meaningful approach for capturing content-related keyword patterns.

Data Analysis: Rstudio, Bibliometrix Package, Biblioshiny Tool

RStudio stands out as a powerful platform for scientific research, especially with the Bibliometrix package. Written in R, Bibliometrix offers comprehensive tools for scientific mapping and bibliometric analysis. The package provides efficient algorithms for the analysis and visualization of data and integrates with a broad scientific ecosystem. RStudio's open-source nature, flexibility, and integration with other R packages make it indispensable in constantly evolving scientific fields (Agnusdei & Coluccia, 2022; Kemeç & Tarakcioğlu Altınay, 2023). It is also the most user-friendly software for bibliometric studies (Moral-Muñoz et al., 2020).

Bibliometrix supports descriptive analysis of the bibliographic data framework, networking for bibliographic matching, co-citation, collaboration, and concurrency analyses. In addition, data visualization techniques such as conceptual structure mapping and network mapping are also prominent features of this package (Aria & Cuccurullo, 2017). It allows both qualitative and quantitative data to be

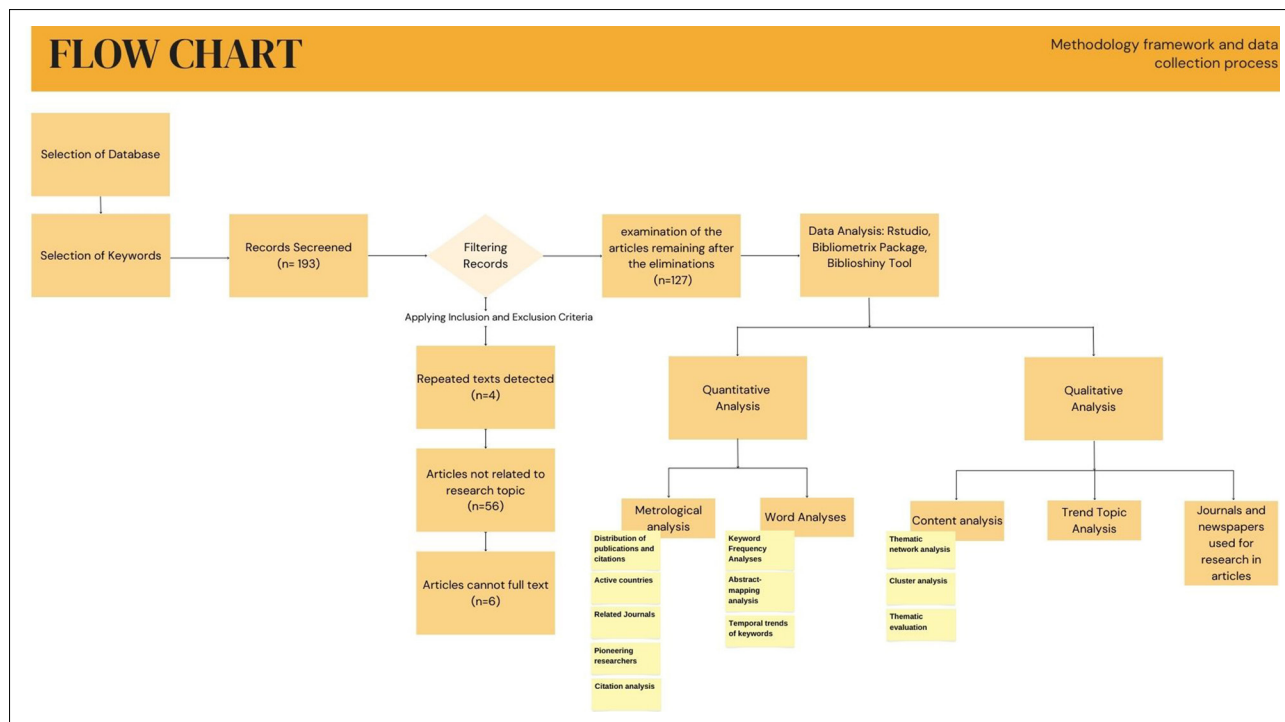


Figure 1. Methodology framework and data collection process (Generated by the Authors).

Table 1. Completeness of bibliographic metadata (Generated by the Authors using Rstudio)

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0	Excellent
AU	Author	0	0	Excellent
DT	Document Type	0	0	Excellent
SO	Journal	0	0	Excellent
LA	Language	0	0	Excellent
PY	Publication Year	0	0	Excellent
WC	Science Categories	0	0	Excellent
TI	Title	0	0	Excellent
TC	Total Citation	0	0	Excellent
CR	Cited References	3	2.36	Good
C1	Affiliation	13	10.24	Acceptable
RP	Corresponding Author	13	10.24	Acceptable
DI	DOI	17	13.39	Acceptable
DE	Keywords	52	40.94	Poor
ID	Keywords Plus	112	88.19	Critical

examined in detail in scientific research, which enables research to be conducted more comprehensively and systematically (Kemeç & Tarakcioğlu Altınay, 2023).

The Biblioshiny tool is a package that includes the core code of Bibliometrix and creates a web-based data analysis framework. This tool allows users to perform bibliometric and visual analyses through an interactive web interface and lowers the threshold of use (Xie et al., 2020). This combination makes it possible to effectively manage multi-stage processes such as collecting, analyzing, and visualizing scientific data.

In conclusion, the main reasons why RStudio is preferred in scientific research are that it is open-source, offers a broad scientific ecosystem, provides access to high-quality statistical algorithms, and offers integrated data visualization tools. These features make RStudio a preferred platform for bibliometric analysis.

The metric analysis comprised the quantitative component, covering annual article count distribution, citations, h-index, and word analysis. The content analysis comprised qualitative components, including thematic network analysis, cluster analysis, and thematic evaluation.

FINDINGS

QUANTITATIVE ANALYSES

Metrological analysis

The metrological analysis is the first stage of the quantitative analysis within the bibliometrics analysis. This section presents the distribution and citations of annual

publications, analysis of active countries based on multiple country publications, single country publication rates, most relevant journals based on the number of documents, researchers based on h-indexes, total citations (TC), number of publications (NP) and citation analysis.

Distribution of publications and citations: The RStudio Bibliometrix analysis provides essential insights into annual document volumes and citations. This review covers metrics such as yearly publication counts, Average Total Citations per Article, Average Citations per Year, and citationable years, visually represented in Figure 2.

According to the number of publication (NP) data, the highest number of articles was published in 2017, with 15, 2018, with 21, and 2016, with 11. MeanTCperArt (Average Total Citations per Article) This metric shows how many citations articles published each year receive on average. One can assess the success of articles published in specific years regarding citation by looking at how this value changes over the years. A single article published in 2003 received 12 citations. With 8.50 citations, articles published in 2021 were effective in receiving citations. MeanTCperYear (Average Citation Per Year) shows the citation rates of articles over the years. This data is essential for studying the citation trends and impact of articles in the long term. The year 2021 stands out with an average of 2.12 citations per year, indicating that recent articles are cited rapidly.

Active countries: A comprehensive analysis of the data produced through RStudio revealed active participation in research on reasons for rework in 30 countries. Table 2 highlights the top 10 countries by number of publications.

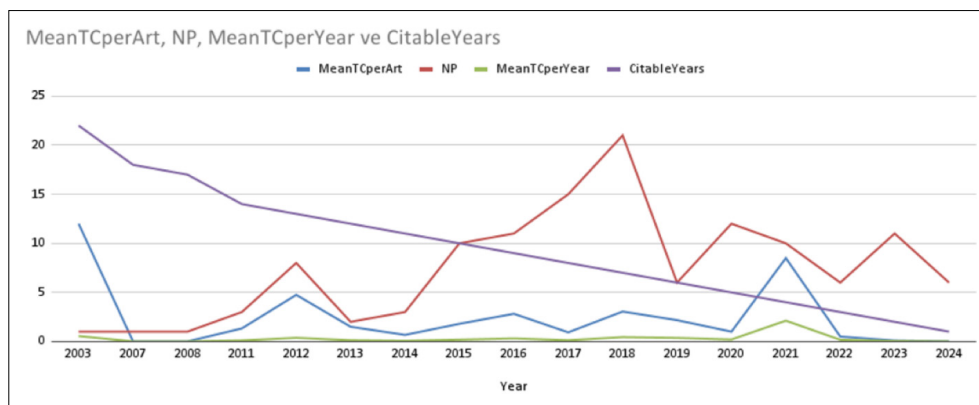


Figure 2. Distribution of publication citations and citations. (Generated by the Authors from RStudio).

Table 2. Total number of articles, SCP, and MCP by the most active countries (Generated by the Authors using Rstudio)

Country	Articles (NP)	Articles (%)	Single Country Publications (SCP)	Multiple Country Publications (MCP)	MCP % Ratio
USA	17	13.4	15	2	11.8
SPAIN	14	11	13	1	7.1
UNITED KINGDOM	14	11	14	0	0
AUSTRALIA	13	10.2	12	1	7.7
CHINA	8	6.3	7	1	12.5
ITALY	7	5.5	7	0	0
NEW ZEALAND	4	3.1	4	0	0
FRANCE	3	2.4	3	0	0
TURKEY	3	2.4	3	0	0

The table includes the number of articles (NP), Single Country Publications (SCP), Multiple Country Publications (MCP), and MCP % Ratio. The USA has published the most articles, with 17. 11.8% of its articles involve international cooperation. Spain and the UK published 14 articles each, but Spain has an MCP rate of 7.1%. It is 0% in the UK, meaning all articles are published nationally. China ranks 5th with 8 articles, but the MCP rate is relatively high at 12.5%.

Related Journals: The dataset of 127 articles published from 2003 to 2024 includes contributions from 38 journals (Figure 3).

“Journal of Architecture” stands out as the journal with the highest number of publications with 23 articles, followed by ‘Fabrications-The Journal of the Society of Architectural Historians, Australia and New Zealand’ with 11 articles and ‘EGA-Revista de Expresion Grafica Arquitectonica’ with 10 articles.

Productive Researchers: Figure 4 shows the academic productivity of the authors over the years. Hultzs A experienced a marked increase in productivity from 2018 onwards and was actively publishing until 2020. Burns,

K. and Chu, CL. worked intensively between 2016-2018. Corry, R.C. and Hogben, P. actively published between 2015-2017.

Citation analysis: This study conducted a citation analysis to identify and examine the most frequently cited publications. Table 3 shows the prominent articles according to both local and global citations. Hultzs (2020a) and Wittman (2020) have the highest number of local citations (2) and have a balanced impact both locally and globally (**Local Citations** (LC)/ **Global Citations** (GC) ratio 100%). On the other hand, Peters & Halleran (2021) stand out as the most globally cited article, with 78 global citations.

Word analyses

Keyword analysis includes keyword frequency analysis, keyword mapping, and temporal trends of keyword analysis, which are essential elements of the broader quantitative analysis.

The integrity of the bibliographic metadata list (Table 1) shows the status of keywords and keywords-plus values in the dataset as critical and poor. For this reason, subsequent word analyses were performed on abstracts as two-word phrases (bigrams).

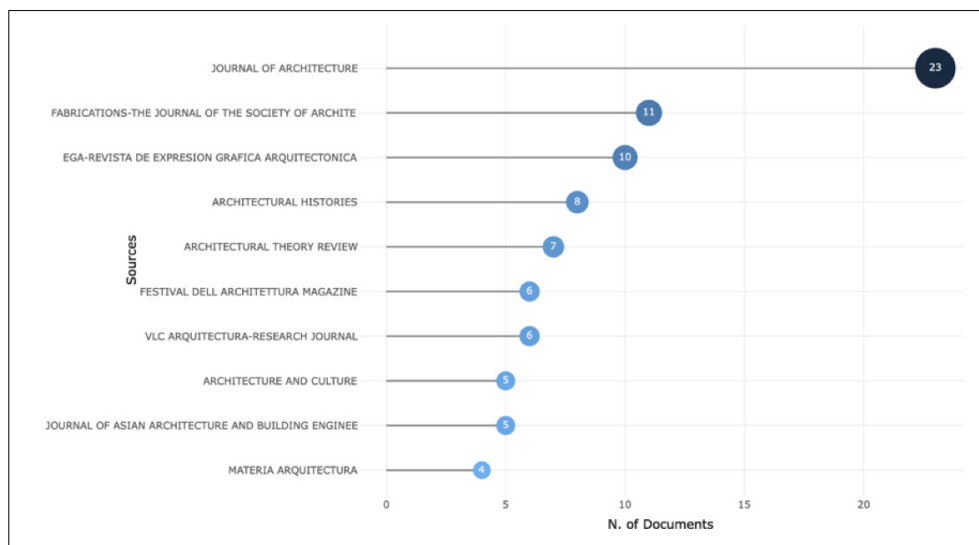


Figure 3. Top 10 journals significantly contributing to research on newspaper and periodicals (Generated by the Authors using Rstudio).

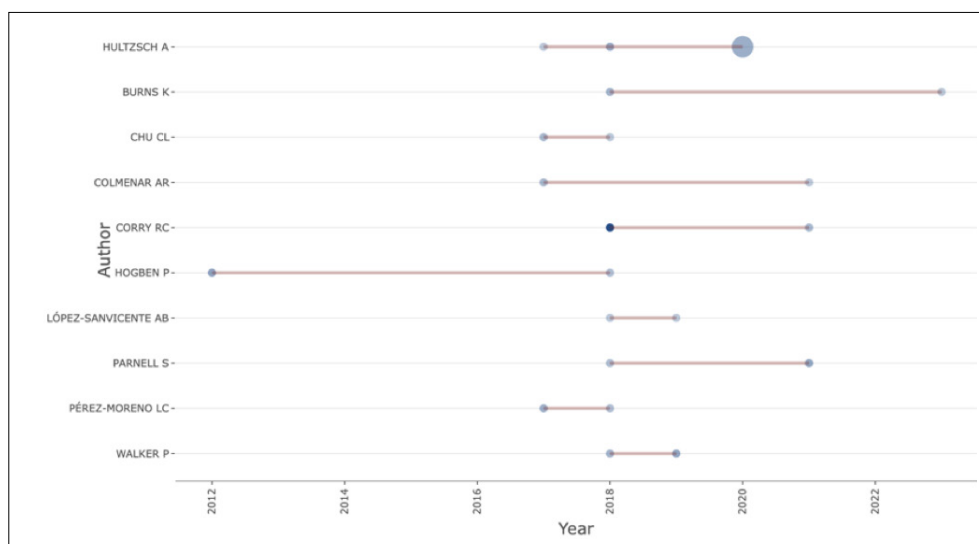


Figure 4. Productivity trends of the top 10 scholars over time (Generated by the Authors using Rstudio).

Keyword Frequency Analyses: According to Figure 5, which visualizes the frequencies of the keywords the authors used most frequently in their studies, subtopics such as history, modernism, Spain, and the 20th century were prominent around the central theme of “Architecture.” These results show that the studies are interested in the history and theory of architecture and focus on Spanish architecture and modernism.

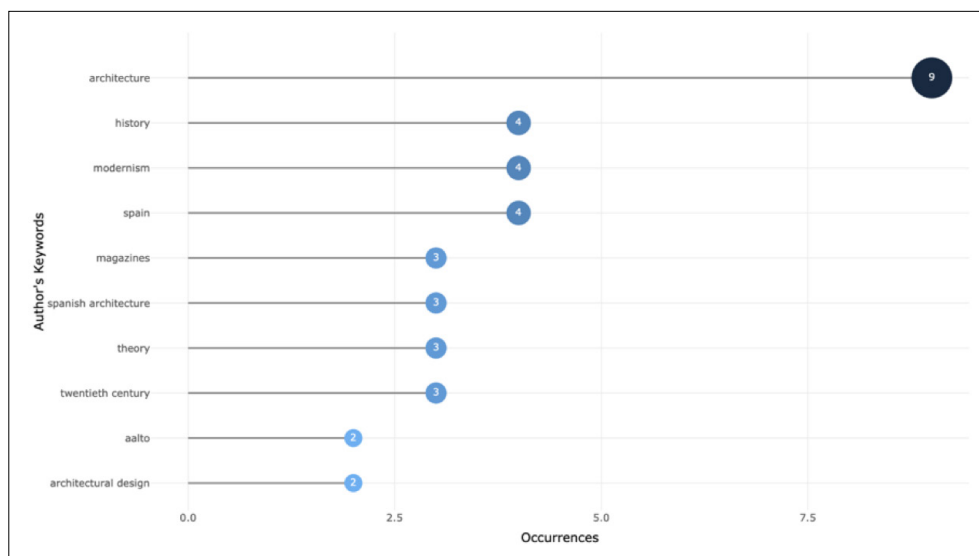
Abstract-mapping analysis: This Co-occurrence Network analysis reveals the most frequently used two-word phrases (bigrams) in the abstracts of the studies and the relationships between these phrases (Figure 6). Each phrase node represents terms used in the literature, and the links represent the relationship between these phrases.

In the graph, terms such as Modern Architecture and Architectural History stand out as the largest and central nodes, highlighting the centrality of these fields in research. The term Twentieth Century is also an essential part of this research. The clusters in different colors show how these terms are grouped and related. For example, the red cluster includes terms such as “architectural theory” and “newspaper,” while in the purple cluster, the terms “urban planning” and “architectural history” are more frequently used together. Smaller clusters, such as social media and online influences, represent more specific areas.

Temporal trends of keywords: The analysis shows how specific architectural themes have emerged in academic

Table 3. The prominent articles, according to local and global citations (Generated by the Authors using Rstudio)

Document	DOI	Year	Local Citations (LC)	Global Citations (GC)	LC/GC Ratio (%)	Normalized Local Citations	Normalized Global Citations
HULTZSCH A, 2020, J ARCHITECTURE	10.1080/13602365.2020.1833962	2020	2	2	100.00	8.00	2.00
RUIZ COLMENAR A, 2017, VLC ARQUIT	10.4995/vlc.2017.7708	2017	1	2	50.00	7.50	2.14
CHU CL, 2017, J ARCHITECTURE	10.1080/13602365.2017.1362025	2017	1	2	50.00	7.50	2.14
WITTMAN R, 2020, J ARCHITECTURE	10.1080/13602365.2020.1828996	2020	1	1	100.00	4.00	1.00
PETERS T. & HALLERAN, A., 2021, ARCHNET-IJAR	10.1108/ARCH-08-2020-0159	2021	0	78	0.00		9.18
METSPALU, P. & Hess, D. B. 2018, PLAN PERSPECT	10.1080/02665433.2017.1348974	2018	0	24	0.00		7.88
KULIC V, 2018, ARCHIT HIST-LONDON	10.5334/ah.273	2018	0	14	0.00		4.59
KULLMANN K, 2016, J LANDSC ARCHIT	10.1080/18626033.2016.1144668	2016	0	13	0.00		4.61
LANGLEY WN, & et. al. 2018, LANDSC J	10.3368/lj.37.1.9	2018	0	13	0.00		4.27

**Figure 5.** Top 10 frequently used words in studies based on keywords (Generated by the Authors using Rstudio).

debates over the years (Figure 7). Modern architecture has become one of architectural literature's most frequently used themes, significantly increasing since 2012. Similarly, the terms architectural history and architectural discourse have steadily increased after 2015. The theme of the world war started to attract attention after 2017, and terms such as landscape architecture and architectural magazines have been used since the 2010s. The geographically specific terms American and Australian architecture show a slow upward trend.

QUALITATIVE ANALYSIS

This section examined themes' development, loss of importance, and potential with Thematic Network analysis; the clustering and relationships of themes based on factor analysis with Cluster analysis; and the evolution of themes over time with Thematic evaluation. Trend Topic Analysis was used to evaluate the change in themes over the years.

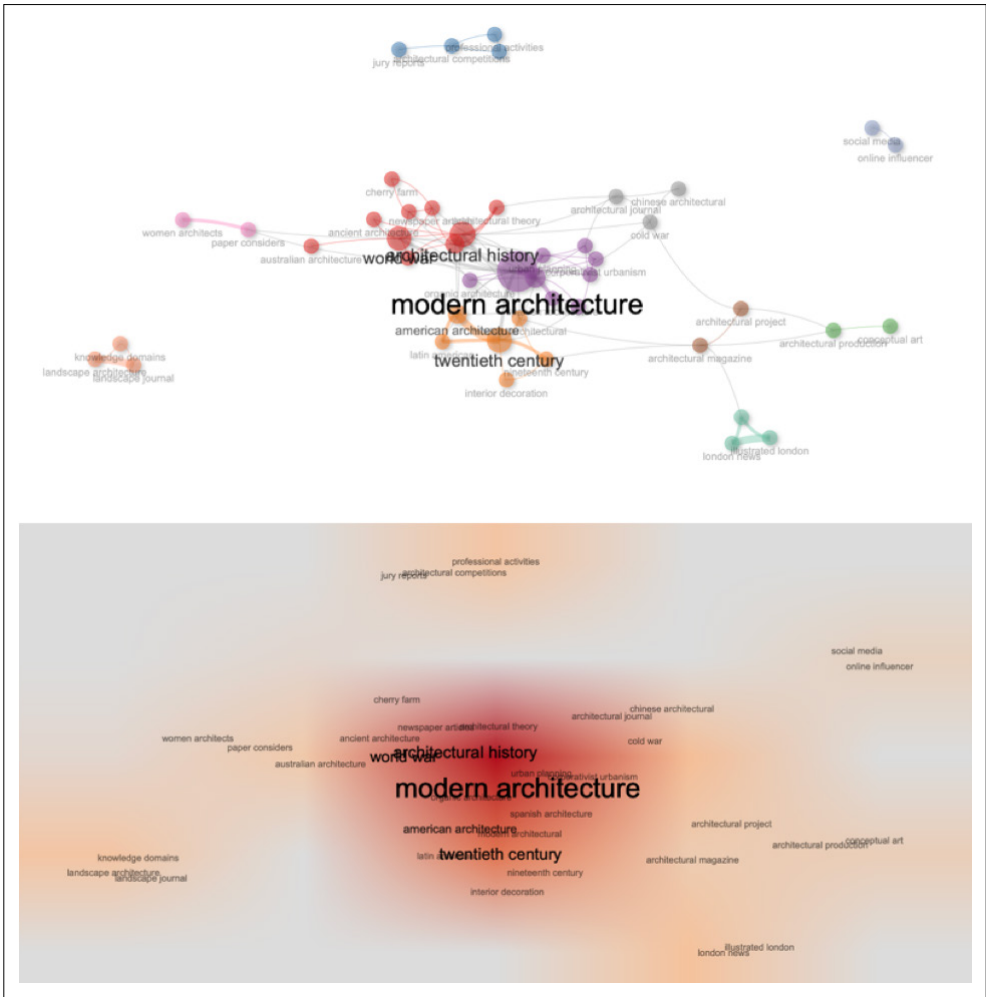


Figure 6. Abstract bigrams based, co-occurrence network analysis (Generated by the Authors using Rstudio).

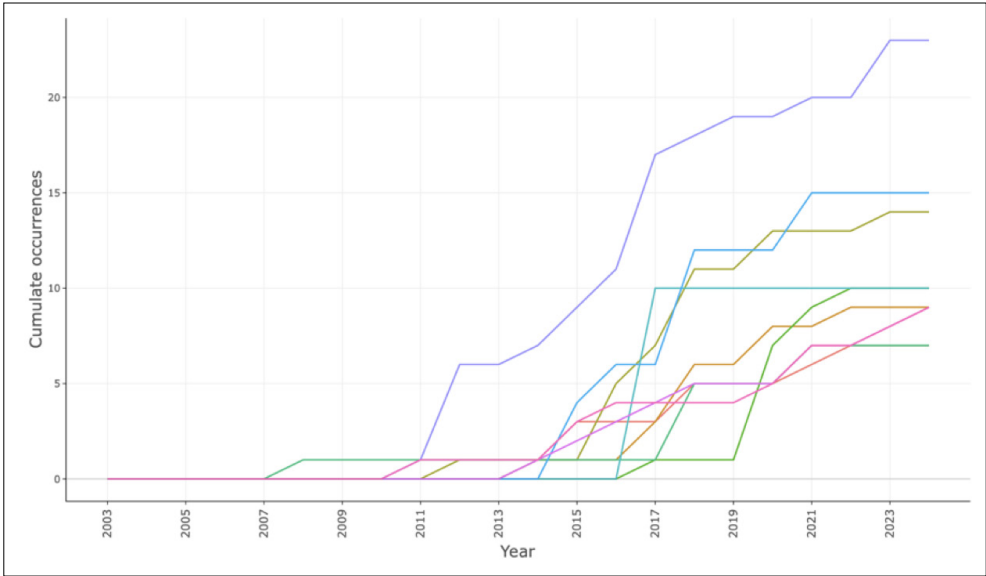


Figure 7. Frequency of word (abstract bigrams) usage over time (Generated by the Authors using Rstudio).

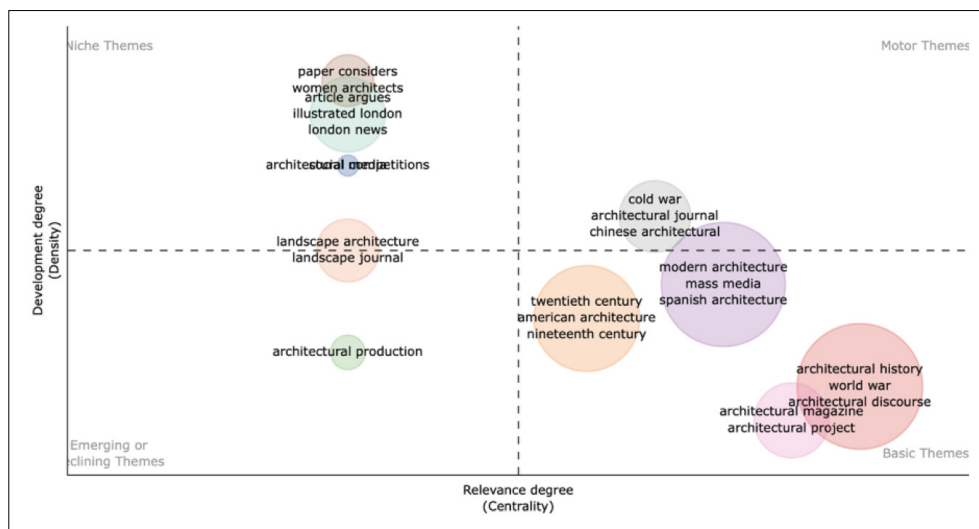


Figure 8. The thematic map (Generated by the Authors using Rstudio).

Content analysis

Thematic network analysis: In Figure 8, the thematic map shows how various themes in the field of architecture are located along the dimensions of density and centrality. On the map, motor themes, such as modern architecture, architectural history, and the twentieth century, stand out as essential and developed, dense, and centralized topics. Niche themes, women architects, and social media stand out as topics studied in depth in specialized fields but are outside the broader academic landscape. Themes such as architectural production in the bottom left-hand corner have low density and centrality and may be either emerging or have lost academic relevance. In addition, core themes such as architectural magazines and architectural projects are identified as widely discussed topics that still need to be covered in depth.

Cluster analysis: Using factor analysis, the graph in Figure 9 shows how the themes related to architecture are distributed in clusters and how they relate to each other. The links between terms can be examined along two main dimensions. The horizontal axis (Dim 1) explains 30.31% of the total variance, and the vertical axis (Dim 2) explains 25.89%.

The analysis is analyzed along two main dimensions: The red cluster, which brings together contemporary issues such as modern architecture, media, and landscape architecture, and shows that terms such as Spanish architecture and modern architecture are particularly prominent in these discussions. The purple cluster includes themes of American architecture and 19th and 20th-century architectural history. The blue cluster includes discussions on architectural theory, western architecture, and world wars. The green cluster is related to more recent architectural projects, academic debates, and publishing; the term cold war is prominent here.

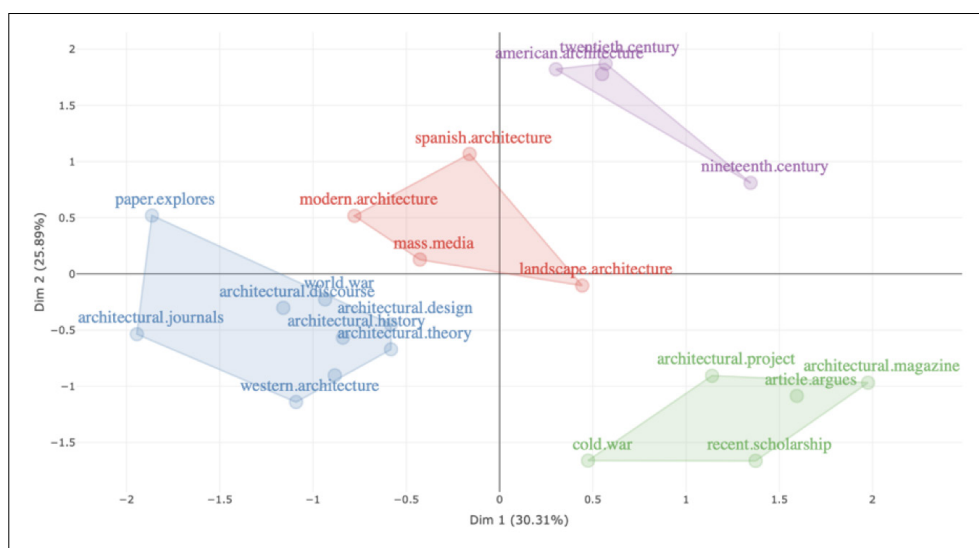


Figure 9. Cluster detection with factorial analysis (Generated by the Authors using Rstudio).

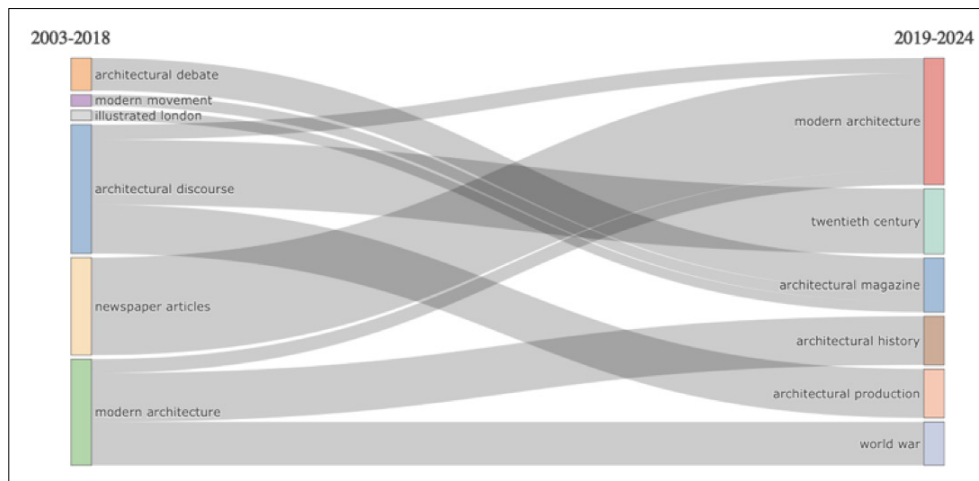


Figure 10. The thematic evolution over time, using Sankey diagram (Generated by the Authors using Rstudio).

Thematic evolution: Figure 10 shows the thematic evolution between 2003-2018 and 2019-2024. This analysis, which visualizes the connections and transformations between the themes between the two periods, highlights how architecture topics have changed over time.

Architectural discourse and newspaper articles were prominent themes in 2003-2018. They show that architectural debates are primarily addressed through print media and general discourses. Topics such as modern architecture and the modern movement reveal that elements of architectural history related to modernism were discussed intensively in this period.

In the 2019-2024 period, the theme of modern architecture

is again at the forefront, and this theme, which has maintained its influence in the previous period, shows that it is still a current focus of interest in the field of architecture. Themes such as architectural magazine and architectural history indicate that the interest in architectural history and publishing has increased in the post-2019 period. Interestingly, the theme of world war has also become prominent in this period.

Trend Topic Analysis

The Trending Topics graph (Figure 11) shows the distribution of terms that have gained prominence and importance over the years.

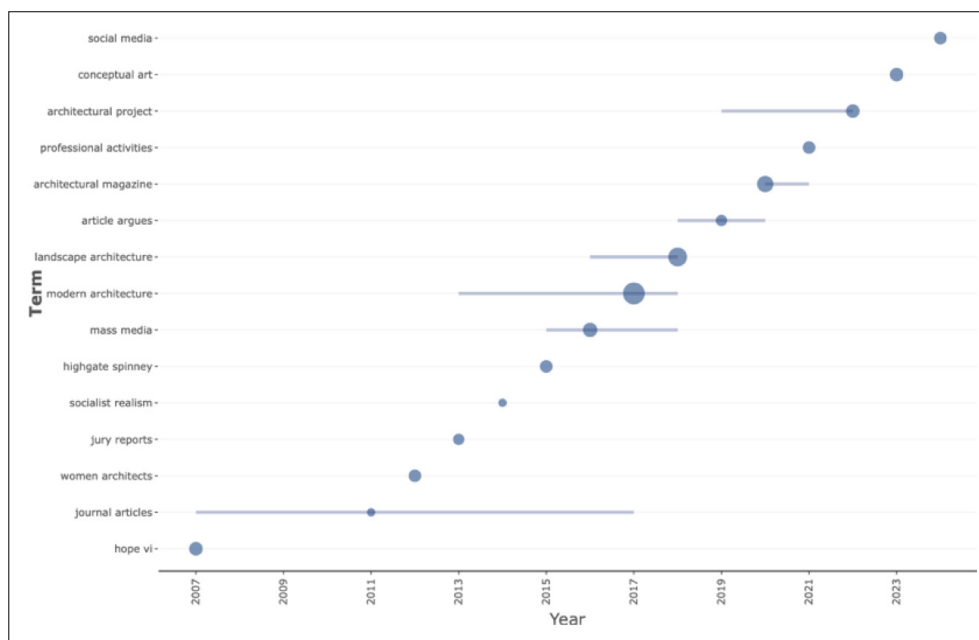


Figure 11. Trend topics in newspaper and periodical studies (Generated by the Authors using Rstudio).

Especially in the post-2020 period, concepts such as modern architecture and social media have become more prominent in architectural debates. Terms such as conceptual art and architectural project, notable in 2011–2013, lost their popularity in this period. On the other hand, niche topics such as women architects attracted more attention in 2015–2017. Notably, terms such as mass media and architectural magazine have also been addressed with increasing interest in the relationship between architecture and media. The size of the terms in the graph reflects their popularity and influence, while their horizontal length reflects the length of time they were discussed. For example, while Modern architecture had a broad impact, terms such as Hope VI were discussed more extensively. The analysis shows that such issues as social media, contemporary architecture, and gender studies are becoming increasingly prominent in architecture.

DISCUSSION

A data set of 127 academic articles published to date, consisting of studies using newspapers and periodicals in architecture, was used. These articles, taken from the WoS (Web of Science) database, were analyzed using the Rstudio program with two analysis methods: Quantitative and qualitative.

Quantitative analyses: Include the distribution of publications and citations, countries of influence, journals where publications were made, and keyword analysis.

There was a fluctuating trend in the number of publications between 2012–2018, with an increase in 2016 (11 articles), 2017 (15 articles) and 2018 (21 articles). This increase can be attributed to the popularity of topics, funding of projects, or academic policies (Figure 2).

When the countries that are active in publications are analyzed, it is seen that countries such as the USA, Spain, and China are more open to international collaborations, and the publications arising from these collaborations can be effective (Table 1). Countries such as the United Kingdom, Italy, and Turkey are more likely to publish at the national level. Countries differ in their academic production strategies and approaches to collaborations. As a result, the scholarly impact of international collaborations is distributed across countries with various approaches, reflecting each country's specific research policies.

The analysis of the most published journals reveals how newspapers and periodicals are used in architectural research and which publications stand out in this field (Figure 3). The "Journal of Architecture" hosts the highest number of publications on the relevant subject with 23 articles because the journal offers various topics. Topics such as the historical development of the architectural profession, its role in public opinion (Hultzs, 2020a; Hultzs, 2020b),

the effects of media and photography on architecture (Sealy, 2016; Popovici, 2014), regional modernism and identity (Seng, 2017; Pérez-Moreno, 2017; Vergara & Pizza, 2021; Özer & Yücel, 2018; Poppelreuter, 2012) come to the fore. This broad perspective and scope make the journal widely preferred in academic studies and provide a comprehensive analysis of different transformations within architecture.

"Fabrications - The Journal of the Society of Architectural Historians, Australia and New Zealand" has one of the highest number of articles because of its in-depth focus on the history of architecture. These articles address the region's architectural developments and international influences, as well as issues such as the search for postcolonial identity and the documentation of local architectural heritage (Walker & Burns, 2018; McLaughlan, 2012; Matthews, 2008; Memmott & Davidson, 2008; McCarthy, 2011). The journal emphasizes the relationship of architectural practices with social sciences and cultural studies, making it a publication that appeals to a broad academic audience.

The reason for the high number of articles in "EGA-Revista de Expresión Gráfica Arquitectónica" is the journal's focus on architectural history and graphic representation. The articles examine architectural representations (Morán García, 2023; Sánchez, 2015), architectural history, and drawing techniques (Ruiz Colmenar, 2021; Mendoza Rodríguez et al., 2017; López-Sanvicente, 2019; Oliva Meyer, 2014; San José Alonso, 2018) add to the academic appeal of the journal through the media.

Hultzs (2017; 2018; 2020a; 2020b) is distinguished by his continuous productivity and four publications focusing on the relationship between architecture and media from a historical perspective. His first two publications focus on the influence of architectural journals in 19th-century Europe and Britain, while the other two focus on the representation of architectural images in the press during the Victorian era. Hultzs's (2020a) publication was the most cited article locally and globally (Table 3). Chu (2017) examined the impact of modern house design on social and cultural reforms in China. Chu (2018) investigated how architectural images create local and global contrasts in Shanghai and Hong Kong. These studies provide essential analyses of how global images are represented in architecture. Ruiz Colmenar (2017) examined 20th-century Spanish architectural criticism and explored how architectural representations in the Spanish press influenced the perception of architecture in 2021. Both Chu and Ruiz Colmenar have influential citations at the local and global levels.

Walker & Burns (2018) examined the promotion of 1980s Australian architecture and postmodernism. Burns (2023) focused on the relationship between media, architecture, and conceptual art. Langley et al. (2018) examined the knowledge fields of landscape architecture,

and Corry (2021) examined the effects of academic publication processes on landscape architecture. Hogben (2012; 2018) examined the impact of American modernism on Australian architecture and the aesthetic evaluation of Sydney architectural structures. López-Sanvicente & Julian (2018) analyzed Eisenman's "model independence" and architectural renovation processes in Cuenca (López-Sanvicente, 2019). Parnell (2018) and Parnell & Sawyer (2021) examined the transformation of AD and the impact of architectural journals on the profession and culture.

Within the scope of keyword analysis, frequency analysis of the words used was carried out. It shows that subtopics such as history, modernism, and especially 20th-century architecture in Spain are frequently covered around the central theme of "architecture." This reflects an interest in architectural theory and history, with Spanish architecture and modernism receiving more specific attention. The study's engagement with modernism can help us understand the far-reaching influence of this period in architectural history and how it was interpreted in different geographical contexts. Especially considering the influence of modernism on the architectural movements of the 20th century, it is conceivable that the newspapers and periodicals prevalent during this period contributed to the conduct of historical research. It can also be considered an indicator of the emphasis on modernism in these print outlets published in the late 19th and first half of the 20th century. The analysis based on word frequency suggests that studies on the history of architecture are generally analyzed through specific periods, geographical regions, and theoretical perspectives. The emphasis on Spanish architecture provides a significant opportunity to understand the place of regional architectural studies in global architectural debates. Likewise, references to the work of prominent architects such as Aalto suggest that architectural history is also evaluated through personal conceptions of design and innovative architectural practices. Newspapers and periodicals are both a historical source and a tool for understanding contemporary architectural theories.

Qualitative analyses: In qualitative analyses, thematic and trend analyses were conducted. In addition to these, the authors revealed the subjects of the articles, the newspapers and periodicals used in the articles.

Thematic Network Analysis: Thematic map analysis provides a critical perspective in identifying important areas of research in the architectural literature. The fact that motor themes such as modern architecture, architectural history and twentieth century occupy a strong position in terms of both density and centrality indicates that these topics have been studied and widely accepted. It can be argued that these themes still have the potential to expand for researchers.

Niche themes such as "women architects" and "social media" have not yet been studied in depth in academic circles, but are receiving intense research interest in specific areas. The contributions of women architects and the impact of social media on architecture, although not fully explored, may gain more importance in the future. The growing interest in gender studies and the impact of digital technologies on architecture suggests that these themes offer significant research opportunities.

Themes with low intensity and centrality, such as "architectural production", can be considered either as topics that have lost their academic relevance or as topics that have not yet matured. In the thematic map, key themes such as "architectural magazine" and "architectural project," offer broad research areas but have not yet been explored in depth. These themes are among the topics that require further research, especially with digitalization and new technologies.

Factorial analysis evaluation: To better understand the thematic structure of the selected articles, a factorial analysis evaluation was conducted using K-means clustering. This process grouped related concepts based on their co-occurrence patterns in article abstracts, identifying four distinct clusters that reveal different aspects of the relationship between media, architectural discourse, and historical developments. These clusters provide insights into the role of newspapers and periodicals in shaping architectural thought.

The visual representation (Table 4) illustrates these clusters. Cluster 1 examines the role of media in architectural discourse through modernization and regional-global interactions. Cluster 2 explores newspapers and periodicals as research tools, emphasizing their historical and theoretical significance. Cluster 3 focuses on architectural journals, their influence on projects, and their role in Cold War narratives. Cluster 4 highlights how journals shaped professionalization, knowledge dissemination, and cultural exchange in the 19th and 20th centuries.

Thematic Evolution: From 2003 to 2018, architectural debates were mainly conducted through "newspaper articles" and "architectural discourse," studies that were associated with modernism. Between 2019 and 2024, while the theme of "modern architecture" continued, the themes of "architectural magazine," "architectural history," and "world war" came to the fore, and research focused on modern architecture, architectural history, and the effects of wars.

The thematic shifts observed between these two periods reflect both the continuing influence of modern architecture and the growing importance of historical events and publishing in the discipline of architecture. These shifts call for a reassessment of architectural practice and theory in a broader context, emphasizing the discipline's ever-evolving nature and the impact of historical events.

Table 4. Factorial analyses evaluation with content of studies (Generated by the Authors)

	Main Themes	Content	Relevant Studies
Cluster 1: Modernization, Regional Approaches in Architecture, and Global Interactions	The Role of Media in Architectural Discourse and Modernity	Architectural magazines and newspapers contribute to the formation and evolution of architectural discourse.	Pozzi (2015), Ruiz Colmenar (2017)
	The Reconstruction of Local Architectural Narratives through Media	How does media reshape architectural discourse at the local level?	Chu (2017)
	Regional Influences of Modernism	The impact of Western modernism on Korean architecture, urban modernization processes, and collective memory	Seo (2017), Méndez & Ramírez (2016)
	The Dissemination of Modern Architecture in the Mediterranean	How modern architecture was integrated into the Mediterranean region through media and magazines	Vergara & Pizza (2021)
	Architecture, Media, and Political Discourse	The role of media in using architecture as an ideological tool (socialist architecture, fascist regimes, Orientalism)	Daunt & Gosseye (2023), Kulic (2018), Rifkind (2012)
	Media and Interdisciplinary Engagement in Landscape Architecture	How media represents interdisciplinary engagements and publishing processes in landscape architecture	Kullmann (2016), Langley, Corry & Brown (2018), Cushing & Renata (2015), Corry (2021)
Cluster 2: The Role of Media and Publications in Architecture – History, Theory, and Discourse	Visual Culture and Architectural Discourse	How visualization technologies and media reinforce architectural narratives	Özemer (2015), López-Sanvicente & Julián (2018)
	Media Representations and Architectural Discourse	How does media represent socialist architecture within ideological frameworks?	Kulic (2018)
	The Regional Impact of Western Modernism	The influence of Western modernism on Korean and Indonesian architecture; the use of journals as primary sources	Seo (2017), Mahatmanto (2015)
	The Relationship Between Engineering and Modern Architecture	How do newspaper and journal archives reveal the relationship between engineering and modern architecture?	Graus (2023)
	Psychoanalytic Theory and Spatial Perception	How do journals and articles explain spatial perception through psychoanalytic theory?	Poppelreuter (2012)
	The Role of Newspaper and Periodical Archives in Research	The use of newspaper and periodical archives as critical sources for historical and theoretical analysis in architectural research	Seo (2017), Mahatmanto (2015), Graus (2023), Poppelreuter (2012)
Cluster 3: Architectural Journals, Periods, and Projects	Architectural Journals and Discourse Production	How architectural photography reproduces the architectural experience, modern representation of Mediterranean architecture, theoretical and project discussions in Lotus' first thirty years	Borree (2022), Sánchez (2015), Marzo (2018)

Table 4. Factorial analyses evaluation with content of studies (Generated by the Authors) (Cont.)

Main Themes	Content	Relevant Studies
Cluster4: The Influence of Journals on 19th and 20th Century Architectural Culture	The Impact of Architectural Journals on the Profession	Hultzsich (2020a), Parnell & Sawyer (2021)
	Architectural Projects and Publications	Sánchez (2015), Fernandez & Villarias (2022)
	Cold War Era Publications, Architecture, and Ideology	Keller (2023), Kulic (2018), Gao et al. (2022)
	Architectural Journals and Professional Practice	Hultzsich (2020b)
	Newspapers and Interior Design Education	May (2017)
	Dissemination of Architectural Imagery and Public Perception	Hogben (2018), Morán-García (2023)
	Colonial-era Architectural Publications	Walker & Achmadi (2019)
	Media and Architectural Criticism	Ruiz Colmenar (2017)
	Professionalization of Architecture Offices	Quici (2022)
	Intellectual Divisions in Architectural Culture	Giudice (2014)
	Architectural Sketches and Historical Influence	Frajndlich (2024)
	Cultural Dissemination, Modernist Projects and Urban Continuity with Publications	Grajales (2016), Radulj & Novaković (2023), Daunt & Gosseye (2023)
	The Influence of Architectural Journals on Discourse	Bosnia-Herzegovina and urban adaptation processes. The influence of religious buildings on urban planning through newspaper analysis
		The impact of Oppositions journal on 1970s architectural culture Zuliani (2018)

Relational Interpretation of Quantitative and Qualitative Findings

This section examines the overlaps and differences that emerge from combining the quantitative and qualitative analyses used in the study. Notable relationships were observed between quantitative indicators, such as citation data, keyword trends, journal and country distributions, and qualitative data, including thematic maps, content clusters, and evolutionary analysis.

First, concepts with high frequency in keyword analysis (e.g., modern architecture, architectural history, representation) also stand out in qualitative content analysis with high centrality and density levels (e.g., “modernism” and “20th-century architecture” themes in Cluster 1, and “representation” in Cluster 3 have high centrality values). This overlap indicates a meaningful discursive continuity between the two methodological levels.

Second, during the period of increased publication numbers between 2012 and 2018, themes that emerged in qualitative analyses (e.g., identity, media, discourse) also gained prominence during these years. (For example, studies published between 2015 and 2018, such as those by Pozzi, Seo, López-Sanvicente, and Langley, coincide with both the period of increased publication numbers and the center of the thematic clusters). This parallelism indicates that thematic intensity and academic interest developed simultaneously over time.

Third, examining the thematic focus of countries with high publication output (e.g., the US, Spain, the UK, Australia, China) suggests that geographical context may influence research preferences. Quantitative data, such as the fact that the US's articles are primarily based on its sources, but also involve international collaboration, and that Spain engages in more international collaboration than the UK, suggest that national and international collaboration may influence countries' thematic choices.

Fourth, there is a high level of alignment between the journals with the highest number of publications and thematic clusters. Journals such as *The Journal of Architecture*, *Fabrications*, and *EGA-Revista de Expresión Gráfica Arquitectónica* focus on themes such as modernism and media theory; regional identity and postcolonial narratives; architectural drawing and historical representation, respectively (for example, most of the modernism-themed studies in Cluster 1 were published in *The Journal of Architecture*). This alignment demonstrates that conceptual approaches to the media-architecture relationship are also reflected in the journals' publication policies.

Finally, some highly cited studies (e.g., Peters & Halleran, 2021, with 78 global citations) do not directly align with the central themes of the content clusters. However, studies such as Hultzsich (2020a) have received significant citations in their local context but have not been directly highlighted

in terms of thematic centrality. This situation demonstrates that not only content depth, but also publication channel, timing, and theoretical background, are crucial for academic visibility.

These findings reveal the complementary nature of quantitative and qualitative methods, shedding light on the multi-layered structure of research on media-architecture relations.

CONCLUSION

This study aims to evaluate the role of newspapers and periodicals in architectural research and examine these media's contribution to the discipline through quantitative and qualitative methods. The data obtained by analyzing 127 articles in the Web of Science (WoS) database shows how these publications have become essential research tools in architecture. The research is limited to newspapers and periodicals (magazines, little journals, and journals); other media types (such as TV, radio, and social media) are omitted. The study comprehensively analyzes how the media influence architectural discourses and public opinion formation. It draws attention to the importance of these sources in shaping architectural history, public perception, and critical perspectives.

The research results detail the dimensions of the contribution of newspapers and periodicals to architectural research. While quantitative analyses addressed the annual distribution of publications in this field and metric data such as the number of citations, qualitative analyses revealed the role of newspapers and periodicals in architectural discourses through a content-based approach. It was found that the increasing number of publications in the years 2012–2018 indicates a growing academic interest in the relationship between architecture and media and that journals such as *Journal of Architecture*, *Fabrications* and *EGA-Revista de Expresión Gráfica Arquitectónica* are among the prominent publications in this field. Through specific keyword analysis, the study also reveals that architectural research focuses on topics such as modernism, social media, gender, and landscape architecture. These findings confirm the media's influence on the critical issues addressed in architectural research and its power to shape architectural discourse in a social and cultural context. Studies on architecture using newspapers and periodicals cover various topics, from historical analysis to theoretical evaluations. Specific thematic analyses and clustering techniques were applied in the research, and in-depth analyses that different methods could provide were not included. However, the thematic and clustering analyses emphasize the impact of international collaborations on academic production and discourse diversity by addressing the contributions of media tools to architectural research in the context of different periods and geographies. International collaborations and the potential of regional architectural journals to increase

cultural interactions provide diversity and richness in the architectural discipline, allowing discourses from different geographies to contribute to academic production.

The study shows how newspapers and periodicals transform the transmission of knowledge about the history of architecture. It is found that architectural magazines not only document the architectural movements of a particular period but also reflect how these movements are perceived and evaluated by society. Magazines play a vital role in promoting, criticizing, and preserving a particular architectural style or project in the public memory, thus ensuring that these structures have a longer-lasting place in the social memory. In this context, it is seen that newspapers and periodicals significantly impact the history of architecture and that the buildings designed by architects are considered physical entities and phenomena reconstructed in the media and social memory. Another essential part of this study is examining how newspapers and periodicals are used in architectural research and identifying the primary sources contributing to the body of knowledge in the field. The analysis reveals the essential newspapers and periodicals frequently consulted in architecture and highlights the data potential these publications offer to academic studies. The study results show how important the use of the print outlets in architectural research is in examining the impact of regional developments on architecture and in understanding various aspects of the discipline.

This study makes an essential contribution to the literature by systematically analyzing the contributions of newspapers and periodicals to architectural research. They are valuable sources for researchers who want to understand a particular period's social, cultural, and technological context. They are used as multifaceted sources of information, for example, the transmission of historical events, the shaping of social perception, and the criticism of architecture. This study discusses them comprehensively to close the knowledge gaps in the literature. In this context, journals that can be consulted and published for studies that use sources such as newspapers and periodicals as data collection tools are presented.

One limitation of this study arises from its keyword-based search strategy, which focused solely on terms related to printed media (e.g., “newspaper,” “periodical,” “magazine,” “press”). As a result, emerging themes such as artificial intelligence, digital media, health-oriented design, and sustainability are underrepresented. This exclusion reflects not a lack of relevance but a constraint inherent in the search criteria. Future research could provide a more comprehensive framework for how media intersects with architectural thought and practice in changing contexts by expanding the scope of keywords to include interdisciplinary and technology-focused concepts.

The bigram analysis employed in this study partially mitigated the limitations resulting from the lack of keyword metadata in the articles. However, since the bigram method only analyzes word pairs that follow each other in the abstract, it cannot fully reflect the context of the original keywords and the authors' conceptual preferences. This limits the sensitivity of the thematic analyses in this study. Future studies would benefit from using detailed content analysis or manual coding techniques on full texts to overcome this limitation.

The findings indicate that print media retains its importance in historical and theoretical studies; however, its future role in architectural research will be shaped by how it adapts to digital transformations. Newspapers and magazines can evolve beyond being mere archival sources to become critical tools for analyzing the intersection of architecture, communication, and public discourse. They may even become part of social media in everyday life.

As a result, this study evaluates the impact of newspapers and periodicals in architectural research and reveals the effects of these tools on architectural discourse. For future research, it is suggested to focus on how the role of media tools in architectural research will evolve with digitalization and the development of new media technologies. Furthermore, the cultural interactions created by the international diffusion of regional architectural journals offer a rich field of research in understanding the evolving structure of the discipline. In addition, a review of databases other than WoS also has the potential to offer new perspectives.

Based on the findings of this study, several recommendations can be made for future researchers and practitioners. First, incorporating media literacy and critical media analysis into architecture education programs will enable students to evaluate representations of architecture in the public sphere more consciously. Furthermore, developing interdisciplinary collaborations between architecture and media studies will contribute to the methodological and theoretical richness of both fields. It is important to encourage research that examines the impact of new media tools, such as digital and social media, on architectural discourse, public opinion formation processes, and project communication. Finally, evaluating media as an archive and information source will contribute to understanding how architectural practice and history have been documented across different periods.

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REFERENCES

- Agnusdei, G. P., & Coluccia, B. (2022). Sustainable agri-food supply chains: Bibliometric, network and content analyses. *Science of The Total Environment*, 824, 153704. <https://doi.org/10.1016/j.scitotenv.2022.153704>
- Alaily-Mattar, N. M., Akhavan, M., & Hein, C. M. (2021). Marking a new chapter in the history of our city: Newspaper narratives of proposed waterfront star architecture. *European Journal of Creative Practices in Cities and Landscapes*, 4(1), 95–112. <https://doi.org/10.6092/issn.2612-0496/11959>
- Alberti, L. B. (1988). *On the Art of Building in Ten Books* (J. Rykwert, N. Leach, & R. Tavernor, Trans.). MIT Press.
- Arabacı, C. (2004). Basın ve Siyaset Üzerine, Medyada Yeni Yaklaşımlar, Metin Işık (ed.). Eğitim Kitabevi.
- Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975. <https://doi.org/10.1016/j.joi.2017.08.007>
- Başaran İ. G. (2010). The Press in Social Remembering and Forgetting: Our Collective Political Memory's Vision of the Republic [Toplumsal hatırlama/Unutma Sürecinde Basın: Kolektif Siyasî Belleğimizdeki Cumhuriyet Tasavvuru], [Doctoral Thesis], Ege University.
- Borree, S. (2022). Interrogating photography as the site of architectural experience: Reflections on photography in *Der Baumeister*. *The Journal of Architecture*, 27(2–3), 420–440. <https://doi.org/10.1080/13602365.2022.2112261>
- Burns, K. (2023). The material kept the score: Media and material practice in Jennifer Bloomer's constructions, 1985–1992. *The Journal of Architecture*, 28(6), 879–901. <https://doi.org/10.1080/13602365.2023.2279232>
- Carmo, M. (2011). *The Alphabet and the Algorithm*. MIT Press.
- Chu, C. L. (2017). Constructing a new domestic discourse: the modern home in architectural journals and mass-market texts in early twentieth-century China. *The Journal of Architecture*, 22(6), 1066–1091. <https://doi.org/10.1080/13602365.2017.1362025>
- Chu, C. L. (2018). Placing "Asia" Against The "West": Occidentalism and The Production of Architectural Images in Shanghai And Hong Kong. *Architectural Theory Review*, 22(3), 309–337. <https://doi.org/10.1080/13264826.2018.1516681>
- Cohen, B. C. (2015). *Press and foreign policy* (Vol. 2321). Princeton University Press.
- Colomina, B. (2020). Privacy and Publicity: Modern Architecture as a Medium of Mass Communication. [Mahremiyet ve kamusalılık, kitle iletişim aracı olarak modern mimari] (A. U. Kılıç, trans., 3. ed.). Metis Yayınları.
- Corry, R. C. (2021). Visions and expectations for publishing landscape scholarship. *Landscape Journal*, 40(2), 101–111. <https://doi.org/10.3368/lj.40.2.101>
- Cushing, D. F., & Renata, A. (2015). Themes in landscape architecture publishing: Past trends, future needs. *Landscape Journal*, 34(1), 15–36. <http://dx.doi.org/10.3368/lj.34.1.15>
- Daunt, L. M., & Gosseye, J. (2023). From Hilltop Landmarks to Suburban Place Makers: Brisbane's Post-War Religious Territories and Communities. *Fabrications*, 33(1), 80–110. <https://doi.org/10.1080/10331867.2023.2249214>
- de Oliveira Capela, F., & Ramirez-Marquez, J. E. (2019). Detecting urban identity perception via newspaper topic modeling. *Cities*, 93, 72–83. <https://doi.org/10.1016/j.cities.2019.04.009>
- Fernandez, M., V. & Villarías, H. G. D. (2022). The architectural project as an impulse for standard furniture. *VLC arquitectura. Research Journal*, 9(2), 7–37. <http://dx.doi.org/10.4995/vlc.2022.16663>
- Frajndlich, R. U. (2024). Oscar Niemeyer: A hegemonic narrative through croquis. *The Journal of Architecture*, 29(1–2), 164–187. <https://doi.org/10.1080/13602365.2024.2333829>
- Franco, I. D., & Ortiz, C. (2020). Medellín in the headlines: The role of the media in the dissemination of urban models. *Cities*, 96, 102431. <https://doi.org/10.1016/j.cities.2019.102431>
- Gao, Y., Xue, C. Q. L., Tan, G., & Chen, Y. (2022). From South China to the global south: Tropical architecture in China during the Cold War. *The Journal of Architecture*, 27(7–8), 979–1011. <https://doi.org/10.1080/13602365.2022.2154821>
- García Estévez, C. B., García Vergara, M., Graus, R., & Piza de Nanno, A. (2019). From within/From outside: Mass media and the international spread of post-war architecture. *Histories of Postwar Architecture*, 2(4), 1–5. <https://doi.org/10.6092/issn.2611-0075/10595>
- Giudice, E. (2014). The architecture between "Whites" and "Grays": Tools, methods and compositive applications. *Festival dell'Architettura Magazine*, 5(30), 24–31.
- Grajales, F. O., (2016). Alvar Aalto in Mexico: An approach to the diffusion of his work in national publications. *Boletín Académico. Revista De Investigación Y Arquitectura Contemporánea*, 6, 91–107. <https://doi.org/10.17979/bac.2016.6.0.1350>
- Graus, R. (2023). Bridging the gap: Engineer Eduardo Torroja in the post-war networks of modern architecture. *Construction History*, 38(1), 99–115. <http://hdl.handle.net/2117/391696>
- Hayes, N. (2000). Civic perceptions: Housing and local decision-making in English cities in the 1920s. *Urban*

- History, 27(2), 211–233. <https://doi.org/10.1017/S0963926800000237>
- Hogben, P. (2012). Architecture and Arts and the mediation of American architecture in post-war Australia. *Fabrications*, 22(1), 30–57. <https://doi.org/10.1080/10331867.2012.685634>
- Hogben, P. (2018). James Green ('De Libra') and "Sydney Architecture Aesthetically Considered." *Fabrications*, 28(3), 375–400. <https://doi.org/10.1080/10331867.2018.1507321>
- Hornbeck, E. (1999). Architecture and advertising. *Journal of Architectural Education*, 53(1), 52–57. <https://doi.org/10.1162/104648899564349>
- Hultsch, A. (2017). To the great public: The architectural image in the early Illustrated London News. *Architectural Histories*, 5(1), 1–17. <https://doi.org/10.5334/ah.268>
- Hultsch, A. (2018). The Crowd and the Building: Flux in the Early Illustrated London News. *Architecture and Culture*, 6(3), 371–386. <https://doi.org/10.1080/20507828.2018.1530419>
- Hultsch, A. (2020a). From encyclopaedia to magazine: The Loudons, the public, and the architect in 1830s Britain. *The Journal of Architecture*, 25(7), 844–872. <https://doi.org/10.1080/13602365.2020.1833962>
- Hultsch, A. (2020b). Sharing knowledge, promoting the built: The origins of the architectural magazine in nineteenth-century Europe. *The Journal of Architecture*, 25(7), 799–808. <https://doi.org/10.1080/13602365.2020.1841940>
- Keller, E. (2023). 'Some residue of prejudice against atomic power': Oscar Newman's underground city and peaceful nuclear explosions. *The Journal of Architecture*, 28(2), 234–256. <https://doi.org/10.1080/13602365.2023.2181373>
- Kemeç, A., & Tarakçıoğlu Altınay, A. (2023). Sustainable energy research trend: A bibliometric analysis using VOSviewer, RStudio bibliometrix, and CiteSpace software tools. *Sustainability*, 15(4), 3618. <https://doi.org/10.3390/su15043618>
- Kulic, V. (2018). Orientalizing socialism: Architecture, media, and the representations of Eastern Europe. *Architectural Histories*, 6(1), 7. <http://doi.org/10.5334/ah.273>
- Kullmann, K. (2016). Disciplinary convergence: Landscape architecture and the spatial design disciplines. *Journal of Landscape Architecture*, 11(1), 30–41. <https://doi.org/10.1080/18626033.2016.1144668>
- Langley, W. N., Corry, R. C., & Brown, R. D. (2018). Core knowledge domains of landscape architecture. *Landscape Journal*, 37(1), 9–21. <http://dx.doi.org/10.3368/lj.37.1.9>
- Li, K., Rollins, J., & Yan, E. (2018). Web of Science use in published research and review papers 1997–2017: A selective, dynamic, cross-domain, content-based analysis. *Scientometrics*, 115(1), 1–20. <https://doi.org/10.1007/s11192-017-2622-5>
- Lindsay, G. & Sawyer, M., (2021). A constellation of stars: What a local newspaper talks about when it talks about star architecture, *European Planning Studies*, <https://doi.org/10.1080/09654313.2021.1892031>
- Lindsay, G., Sawyer, M., & Alaily-Mattar, N. (2025). Architecture in the age of social media: Introduction to the special issue. *Archnet-IJAR: International Journal of Architectural Research*. <https://doi.org/10.1108/ARCH-03-2025-0114>
- López-Sanvicente, A. (2019). Drawings by Artists in Cuenca: Vernacular Architecture and Urban Regeneration [Dibujos de los artistas en Cuenca: Arquitectura popular y regeneración urbana]. *EGA Expresión Gráfica Arquitectónica*, 24(37), 182–191. <https://doi.org/10.4995/ega.2019.11461>
- López-Sanvicente, A. B., & Julian, I. C. (2018). Eisenman reflecting on the independence of the model as an architectural object. *Disegnare Idee Immagini-Ideas Images*, 29(57), 82–89.
- Lyytimäki, J. (2014). Bad nature: Newspaper representations of ecosystem disservices. *Urban Forestry & Urban Greening*, 13(3), 418–424. <https://doi.org/10.1016/j.ufug.2014.04.005>
- Mahatmanto. (2015). Role of the Journal of Building Engineers in Dutch East India in discussing the emergence of Indonesian modern architecture. *Journal of Asian Architecture and Building Engineering*, 14(3), 529–532. <https://doi.org/10.3130/jaabe.14.529>
- Mallgrave, H. F. (2005). *Modern Architectural Theory: A Historical Survey, 1673–1968*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511497728>
- Marzo, M. (2018). Lotus: The first thirty years of an architectural magazine. *FAMagazine. Research and Projects on Architecture and the City*, (43), 41–66. <https://doi.org/10.12838/fam/issn2039-0491/n43-2018/142>
- Matthews, L. (2008). Parochial matters: The writings of Duncan Richards and Oline Richards. *Fabrications*, 18(1), 24–39. <https://doi.org/10.1080/10331867.2008.10539620>
- May, B. A. (2017). Lessons in diversity: Origins of interior decoration education in the United States, 1870–1930. *Journal of Interior Design*, 42(3), 5–28. <https://doi.org/10.1111/joid.12086>
- McCarthy, C. (2011). Before official statistics: The early commerce of wallpaper in New Zealand. *Fabrications*, 20(1), 96–119. <https://doi.org/10.1080/10331867.2011.10539673>
- McLauglan, R. (2012). Post-rationalisation and misunderstanding: Mental hospital architecture in the New Zealand media. *Fabrications*, 22(2), 232–256. <https://doi.org/10.1080/10331867.2012.733162>

- McLuhan, M. (1962). *The Gutenberg Galaxy: The Making of Typographic Man*. University of Toronto Press.
- McQuire, S. (2009). *The Media City: Media, Architecture and Urban Space*. SAGE.
- Memmott, P., & Davidson, J. (2008). Indigenous culture and architecture in the South Pacific region: 25 years of SAHANZ research. *Fabrications*, 18(1), 74–113. <https://doi.org/10.1080/10331867.2008.10539623>
- Méndez, P., & Ramírez, J. (2016). Images in ink, architecture in ideas: 1960s imprint modernity from the pages of *El Sur*. *ARQ (Santiago)*, (94), 108–117. <https://dx.doi.org/10.4067/S0717-69962016000300108>
- Mendoza Rodríguez, I., Álvaro Tordesillas, A., & Montes Serrano, C. (2017). Architectural Drawing in 1940s Spain: A Study Based on the Revista Nacional de Arquitectura [El dibujo de arquitectura de los años cuarenta en España: Un estudio a partir de la Revista Nacional de Arquitectura]. *EGA Expresión Gráfica Arquitectónica*, 22(29), 170–179. <https://doi.org/10.4995/ega.2017.4168>
- Metspalu, P., & Hess, D. B. (2018). Revisiting the role of architects in planning large-scale housing in the USSR: The birth of socialist residential districts in Tallinn, Estonia, 1957–1979. *Planning Perspectives*, 33(3), 335–361. <https://doi.org/10.1080/02665433.2017.1348974>
- Moral-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., & Cobo, M. J. (2020). Software tools for conducting bibliometric analysis in science: An up-to-date review. *Profesional De La Información*, 29(1), 1–20. <https://doi.org/10.3145/epi.2020.ene.03>
- Morán García, P. (2023). Exploring Architecture through Looking Alone: Image Compositions in La Ilustración Española y Americana (1869–1905) [Recorrer la arquitectura con solo mirar: composiciones de imágenes en La Ilustración Española y Americana (1869–1905)]. *EGA Expresión Gráfica Arquitectónica*, 28(47), 150–165. <https://doi.org/10.4995/ega.2023.17368>
- Ockman, J. (2000). *Architecture Culture 1943–1968: A Documentary Anthology*. Columbia Books of Architecture.
- Oliva Meyer, J. (2014). Graphic Documents on the Education of Architecture Students in Postwar Spain (1940–1953) [Documentos gráficos en torno a la formación de los estudiantes de arquitectura en la posguerra española (1940–1953)]. *EGA Expresión Gráfica Arquitectónica*, 19(23), 92–103. <https://doi.org/10.4995/ega.2014.2180>
- Özemer, S. (2015). Imaging Technologies, Visual Culture, and Architecture From 1962 to Today. [1962'den Günümüze Değin Görüntüleme Uygulamaları, Görsel Ekin ve Mimarlık]. *Megaron*, 10(4), 536–564. <https://10.5505/MEGARON.2015.97759>
- Özer, S. D., & Yücel, Ş. (2018). Environmental challenges and developmental angst: Mimarlık and the early environmental discourse in Turkish architecture. *The Journal of Architecture*, 23(2), 249–264. <https://doi.org/10.1080/13602365.2018.1443488>
- Parnell, S. (2018). Acroshaw: Forgotten, but not Forgiven. *Architecture and Culture*, 6(1), 37–59. <https://doi.org/10.1080/20507828.2017.1386455>
- Parnell, S., & Sawyer, M. (2021). In search of architectural magazines. *Arq Architectural Research Quarterly*, 25(1), 43–54. <http://dx.doi.org/10.1017/S1359135520000457>
- Pérez-Moreno, L. C. (2017). Writing the history of Spanish modern architecture: Texts by Flores and Fullaondo from the 1960s. *The Journal of Architecture*, 22(2), 273–292. <https://doi.org/10.1080/13602365.2017.1299196>
- Peters, T., & Halleran, A. (2021). How our homes impact our health: Using a COVID-19 informed approach to examine urban apartment housing. *Archnet-IJAR*, 15(1), 10–27. <https://doi.org/10.1108/ARCH-08-2020-0159>
- Popovici, I. C. (2014). Architecture competitions – a space for political contention. Socialist Romania, 1950–1956. *Journal of Architecture and Urbanism*, 38(1), 24–38. <https://doi.org/10.3846/20297955.2014.891561>
- Poppelreuter, T. (2012). Sensation of space and modern architecture: A psychology of architecture by Franz Löwitsch. *The Journal of Architecture*, 17(2), 251–272. <https://doi.org/10.1080/13602365.2012.678645>
- Pozzi, C. (2015). Latin America made in Italy: The editorial construction of a domesticated modernism. *ABE Journal. Architecture Beyond Europe*, (7), 10798. <https://doi.org/10.4000/abe.10798>
- Quici, F. (2022). The draftsman's profession in US architecture offices as portrayed on the pages of the magazine *Pencil Points*. *Disegnare Idee Immagini-Ideas Images*, 33(64), 1–339.
- Radulj, M., & Novaković, N. (2023). Towards the new synthesis of architecture and city: Banja Luka's (mega) structures from the 1970s. *Prostor*, 31(2(66)), 198–209. [https://doi.org/10.31522/p.31.2\(66\).5](https://doi.org/10.31522/p.31.2(66).5)
- Rifkind, D. (2012). 'Everything in the state, nothing against the state, nothing outside the state': Corporatist urbanism and Rationalist architecture in fascist Italy. *Planning Perspectives*, 27(1), 51–80. <https://doi.org/10.1080/02665433.2012.629810>
- Ruiz Colmenar, A. (2017). Trends and guerrillas in Spanish architecture: Architecture and press. *VLC arquitectura. Research Journal*, 4(2), 149–177. <https://doi.org/10.4995/vlc.2017.7708>
- Ruiz Colmenar, A. (2021). The Representation of Architecture in the Non-Specialized Press: The Case of ABC

- and Blanco y Negro [La representación de arquitectura en la prensa no especializada. El caso de ABC y Blanco y Negro]. *EGA Expresión Gráfica Arquitectónica*, 26(42), 234–245. <https://doi.org/10.4995/ega.2021.15029>
- Rykwert, J. (1980). *The Idea of a Town: The Anthropology of Urban Form in Rome, Italy and the Ancient World*. MIT Press.
- San José Alonso, J. I. (2018). Surveying, Technology, and Documentation of Architecture [Levantamiento, tecnología y documentación de la arquitectura]. *EGA Expresión Gráfica Arquitectónica*, 23(34), 240–251. <https://doi.org/10.4995/ega.2018.10937>
- Sánchez, V. A. L. (2015). Gio Ponti and Bernard Rudofsky: The Mediterranean House and Its Representation in Domus Magazine [Gio Ponti y Bernard Rudofsky: la casa mediterránea y su representación en la revista Domus]. *EGA Expresión Gráfica Arquitectónica*, 20(26), 256–265. <https://doi.org/10.4995/ega.2015.4059>
- Sealy, P. (2016). After a photograph, before photography (takes command). *The Journal of Architecture*, 21(6), 911–937. <https://doi.org/10.1080/13602365.2016.1220970>
- Seng, E. (2017). Temporary domesticities: The Southeast Asian hotel as (re)presentation of modernity, 1968–1973. *The Journal of Architecture*, 22(6), 1092–1136. <https://doi.org/10.1080/13602365.2017.1365270>
- Seo, M. (2017). Accommodation of Western Modernism in Korean Architecture - A Case Study of Dong-jin Park (1899-1981)-. *Journal of Asian Architecture and Building Engineering*, 16(2), 263–270. <https://doi.org/10.3130/jaabe.16.263>
- Sklair, L., & Gherardi, L. (2012). Iconic architecture as a hegemonic project of the transnational capitalist class. *City*, 16(1-2), 57–73. <https://doi.org/10.1080/13604813.2012.662366>
- Tokgöz, O. (1981). Basic Journalism [Temel gazetecilik] (Vol. 6). İmge.
- Vergara, M., & Pizza, A. (2021). The Mediterranean and modern architecture: The dissemination of a myth in architectural media. *The Journal of Architecture*, 26(8), 1117–1145. <https://doi.org/10.1080/13602365.2021.1980419>
- Walker, P., & Achmadi, A. (2019). Advertising “the East”: Encounters with the urban and the exotic in late colonial Asia Pacific. *Fabrications*, 29(2), 154–183. <https://doi.org/10.1080/10331867.2019.1588686>
- Walker, P., & Burns, K. (2018). Constructing Australian architecture for international audiences: Regionalism, postmodernism, and the Design Arts Board 1980–1988. *Fabrications*, 28(1), 25–46. <https://doi.org/10.1080/10331867.2017.1418192>
- Wittkower, R. (1998). *Architectural Principles in the Age of Humanism*. Academy Editions
- Wittman, R. (2020). Architecture in the Roman periodical press, 1770–1848. *The Journal of Architecture*, 25(7), 809–843. <https://doi.org/10.1080/13602365.2020.1828996>
- Xie, H., Zhang, Y., Wu, Z., & Ly, T. (2020). A bibliometric analysis on land degradation: Current status, development, and future directions. *Land*, 9(1), 28. <https://doi.org/10.3390/land9010028>
- Zuliani, G. (2018). Oppositions 1973-1984. *FAMagazine. Research and Projects on Architecture and the City*, (43), 79–96. <https://doi.org/10.12838/fam/issn2039-0491/n43-2018/137>



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M G A R O N

Article

Material analyses and field applications for the conservation of archeological remains found in the aerial cable car station construction site in Hatay (Türkiye)

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ABSTRACT

During the constructions carried out within the scope of the Aerial Cable Car Project planned by Hatay Metropolitan Municipality, archaeological remains were discovered in İplik Pazarı District where a station was going to be built, and upon that discovery, rescue excavation works were started in 2012 for the conservation of the remains. This article deliberates the material analyses of the archeological remains performed during the preparation of the survey, restitution, and restoration projects; the field inspections and the small-scale intervention trials on the remains carried out during the implementation phase of the cable car project; the suggestions developed for the conservation of the remains based on these studies, and the conservation practices carried out in line with these suggestions. In this context, the determined characteristics of the stone, brick, and mortar samples taken from the remains were given, recommendations for the consolidation mortar and injection grout compositions were presented, and the field applications carried out in line with these recommendations were outlined. Other conservation activities were also addressed, such as the methods used in the fight against algae formation on the wall surfaces and works conducted for repairing terracotta pipes and sarcophagi.

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INTRODUCTION

Being a region that has a moderate climate and fertile lands located at the crossroads that connect Anatolia to Syria and Palestine via the Çukurova Plain and that harbors the most expedient ports to reach the Mediterranean from Mesopotamia, Hatay has been one of the most sought-after

destinations susceptible to flows of immigration and has been the host land for many cultures throughout history. Antakya, the central town of Hatay, is one of the settlements most destroyed by earthquakes throughout history. Antakya experienced its first known earthquake in 148 BC (Adams & Barazangi, 1984). Earthquakes encountered in

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130 BC, 37, 115, 458, 525, and 526 AD are recognized as the major earthquakes that hit the city. The most severe of these, and the one that caused the most loss of life, was the earthquake that occurred in 526. In this earthquake, 250-300,000 people died (Beyen et al., 2003). The city is known to be subject to essential earthquakes in 528, 551, 557, 560, 577, 588, 750, 841, 859, 868, 1053, 1090, 1157, 1169, 1303, 1406, 1759, 1787, 1822, and 1872 (Beyen et al., 2003). Earthquakes in 1157 and 1169 caused extensive damage to Bakras Castle. Two other severe earthquakes that occurred in the area in 1615 and 1872 caused great destruction in Antakya and its villages (T.C. Hatay Valiliği, 2019). Later on, the earthquakes that happened in Hatay were light and therefore non-damaging (Beyen et al., 2003). Unfortunately, after the earthquake on February 6, 2023, great destruction and loss of life were experienced in the center of Hatay and the surrounding districts, and many cultural assets were demolished or damaged.

The route of the Aerial Cable Car Project, planned by Hatay Metropolitan Municipality, is adjacent to the Phyrminus (Hamşen) River, which has been partially covered and taken under the road passing over it today. Upon discovering archaeological remains during the works carried out in the project area (İplik Pazarı District), a rescue excavation was started promptly in 2012. The findings obtained during the rescue excavation indicate that this area is a part of the settlement belonging to the city of Antiokheia, and the architectural structures and finds unearthed in the area point out the presence of Roman, Byzantine, Islamic, and Ottoman Periods, respectively.

This article discusses the conservation of the aforementioned archeological remains completed before the earthquake on February 6, 2023. In this context, results of the laboratory examinations carried out on the samples taken from the walls, procedures and practices for the consolidation of the walls by pointing and grout injection according to the outcomes of the laboratory work and field inspections, the removal of algae, the cleaning and assembly of earthenware pipe and terracotta sarcophagus fragments, and furthermore, a preliminary observation about the general condition of the consolidated walls after being subjected to the earthquake, are presented. The laboratory work revealed the types of the sampled stones and the mechanical properties of the sampled stones, bricks, and mortars. The ingredients of the consolidation mortars (pointing mortars) were determined according to the binder-aggregate ratio and granulometry of the mortar samples identified by laboratory analyses. Consolidation of the walls included grout injection since the field inspections showed the presence of internal gaps in the walls that needed to be filled to overcome discontinuities and achieve structural integrity. The composition of the grout was decided through simple tests applied to trial grouts at the worksite. Through finalizing the last part of

the fieldwork, including the removal of algae with biocide application and the cleaning and repair of earthenware pipes and terracotta sarcophagi, in-situ conservation and presentation of the architectural remains with related archaeological finds were performed within the frame of a holistic approach.

THE WORKSITE: ARCHAEOLOGICAL REMAINS AND STATION CONSTRUCTION

During the archaeological work, rooms of a settlement belonging to the Roman Period were discovered (Figure 1), whereas remains from the Byzantine and Ottoman periods were also unearthed, which are all well below the elevation level currently in use due to the stratification built up over the centuries. Through the archaeological work, it was determined that modifications, including the use of spolia, and repairs were made during each main period of the building (Pamir & Sezgin, 2016). Although the remains carry features from different periods, the structure is assumed to be a Villa Urbana type Roman building in general terms. The entrance of the building, which has commercial units facing the street on both sides, appears to be located in the north direction, adjacent to the atrium (main hall). The entrance section, where the triclinium (dining room) and atrium are placed and covered with mosaics, can also be read as an example of a quintessential garden arrangement, which is frequently seen in Roman villas. The dining area, which is adjacent to this garden at the entrance, is believed to be located at the center of the building, with other spatial usages surrounding these two main areas.

A monochrome (white) figureless floor mosaic is laid in the entrance of the villa, and the Three-Panel Mosaic with Figures (Figure 2) located in the dining hall is dated to the 3rd or 4th century AD. The Greek inscription on the mosaic conveys enjoying, having fun, and cheering up (Pamir & Sezgin, 2016).

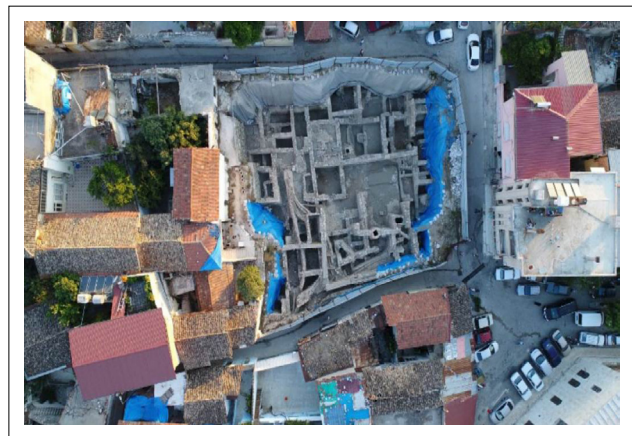


Figure 1. General view of the excavation area.

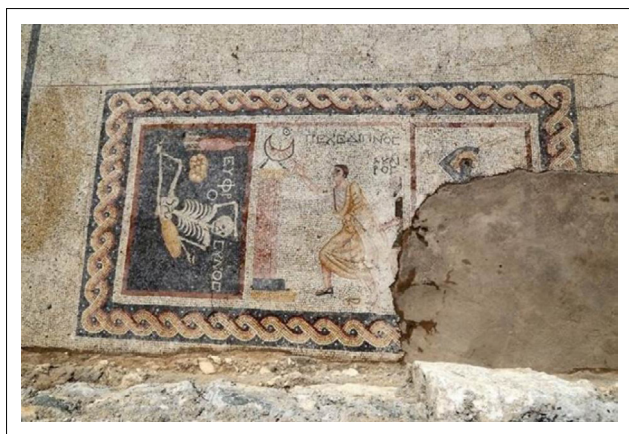


Figure 2. Three-Panel Mosaic with figures.

While the Aerial Cable Car Project construction was ongoing, a transparent protective platform was built over the excavation area, using mainly steel and glass, to protect the remains from external factors and allow them to be seen by visitors. The aerial cable car sub-station structure that will rise over the remains is located approximately 8 m above the glass platform. The superstructure of the aerial cable car is associated with the remains by means of its main load-bearing elements. At the locations of the load-bearing elements, the archaeological remains were temporarily removed and partially moved back after the construction was completed. For the main load-bearing elements, foundations were dug by hand. The glass platform is designed to enable the remains to be perceived holistically, as well as to combine the different elevations currently in use around the excavation area and establish the relationship of the navigation route with them.

DETERMINATION OF THE PROPERTIES OF THE BUILDING MATERIALS

On-site inspections and sampling

During the on-site inspections conducted in November 2014, the ground floor floors of the building were determined to be made of limestone slabs, whereas the walls were built with stone and brick (Figure 3; Figure 4). Two types of stones and three types of bricks of different heights (thickness) were determined throughout the building. The heights of the bricks are 40 mm, 35 mm, and 50 mm; the width and length of a 35 mm-high brick, of which all dimensions can be measured, were observed to be approximately 300x300 mm in size, whereas the mortar in the joints was seen to vary between 20 and 40 mm in height. In addition, on some bricks, 8 mm wide and 1 mm deep diagonal grooves were identified that were opened to increase the adherence between brick and mortar (Figure 4).

In order to determine the other properties of the building materials and to be able to make material



Figure 3. The different types of stones that were used throughout the structure.



Figure 4. The grooves on a brick.

recommendations that would be appropriate to be used for the consolidation works, six stone, three brick, and three mortar samples were taken from the locations identified in the Roman building remains. Locations of the samples were marked on the scaled survey drawings (Figure 5). Building materials that were loosened or disintegrated in their original location were determined through a visual inspection and were chosen for sampling to minimize the probable damage to the adjacent sound materials in better condition.

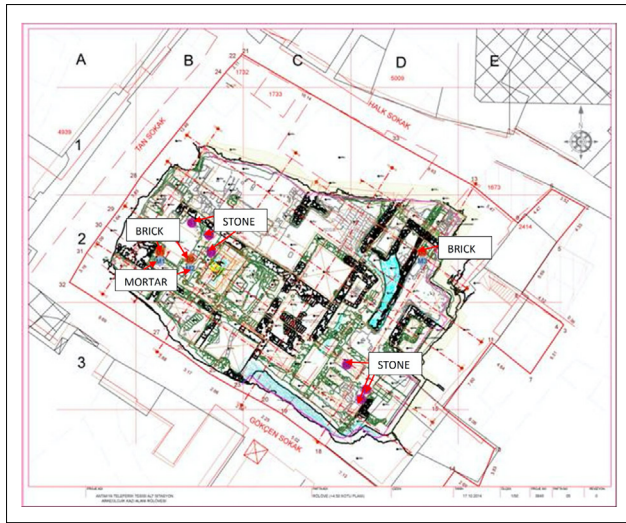


Figure 5. Location of the samples (purple marks represent natural stones, orange marks represent bricks and blue marks represent mortars).

Laboratory works and findings

The samples taken from the site were brought to the Construction Materials Laboratory of the Faculty of Civil Engineering at Yıldız Technical University. 43 specimens (24 stone, 13 brick, and 6 mortar) were prepared from the samples. The results of the examinations, analyses, and tests carried out on these samples and specimens are given below.

Natural Stones: Through visually conducted on-site and laboratory inspections, two types of natural stones were identified as being used in the structure: sedimentary and igneous rocks. The sedimentary rocks used throughout the building are two types of limestone. One of them is a massive, non-porous, fine-grained, crack-free, non-clay-bearing, strong, limestone (represented by samples Stone 1 and Stone 3) with a light white-cream color, and has a weathering degree of W1 according to the ISRM (International Society for Rock Mechanics) classification (Chala & Rao, 2021; Brown, 1981). The other one is a yellowish-cream colored, strong, non-clay-bearing dolomitic limestone (represented by sample Stone 2), which contains few dissolution voids, and has a weathering degree of W2. Samples taken from another rock type, which was seen to be used less frequently in the structure, revealed to be igneous plutonic rocks. The samples examined in this group were lead gray-colored, strong, microlithic gabbro-type fine-grained basic rocks (represented by samples Stone 4 and Stone 6) with weathering degrees of W1-W2, and a slightly serpentinized gabbro-type basic rock (represented by sample Stone 5) with a weathering degree of W2-W3.

The natural stone samples brought to the laboratory were cut with a stone-cutting machine; thus, cube samples of

(50±5) mm were prepared in accordance with TS EN 1926 (TSE, 2013). The uniaxial compression test was carried out with a 60-ton capacity loading device. The uniaxial compressive strength (N/mm²) was calculated as the ratio of the breaking load to the cross-section of the specimen (Table 1).

Within the scope of physical properties of the stone samples, real density, apparent density, and total and open porosity of the specimens were determined (Table 2) according to TS EN 1936 (TSE, 2007). Moreover, their water absorption (Table 2) was identified, and capillary water absorption curves were drawn (Figure 6) to calculate the capillary water absorption coefficient in line with TS EN 15801 (TSE, 2010) using cube specimens prepared with dimensions of 50±5 mm. However, since there was very little to no capillary water absorption on the surfaces of the specimens within the first hour, the regression line could not be drawn on the graph, and the capillary water absorption coefficient could not be determined.

Limestones used throughout the building were detected to be extremely high-strength, and the samples taken from them have an average uniaxial compressive strength of 103.6 N/mm² according to TS EN 1926 (TSE, 2013). Results of the uniaxial compression test applied to the limestone specimens are presented in Table 1. The physical tests applied to the limestones (Table 2) revealed an average apparent

Table 1. Uniaxial compressive strength of the stone specimens.

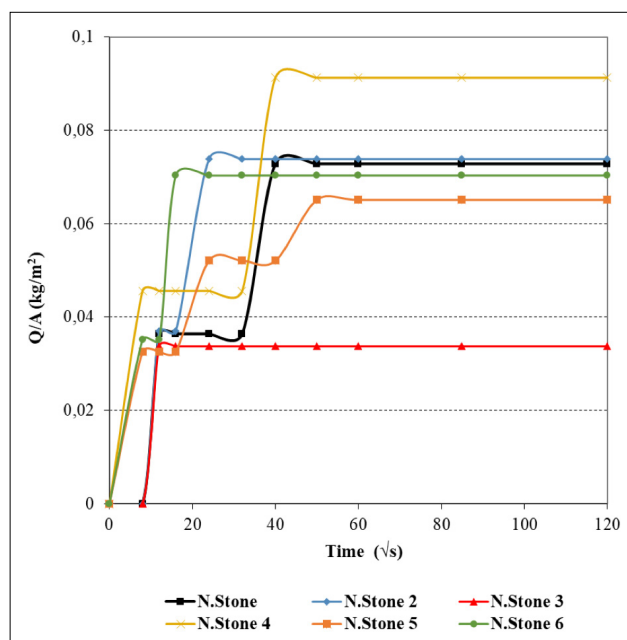
Sample code	Uniaxial compressive strength (N/mm ²)	Average uniaxial compressive strength (N/mm ²)
Stone 1	139.4	115.7±17.0
	107.0	
	100.6	
Stone 2	124.6	106.3±12.9
	96.9	
	97.4	
Stone 3	119.7	88.7±23.0
	81.4	
	64.9	
Stone 4	84.9	104.7±24.5
	139.3	
	89.9	
Stone 5	98.1	*
Stone 6	84.2	123.3±30.2
	127.6	
	158.0	

* Due to the dimensions and geometry of the stone sample, only one specimen could be prepared in accordance with the standard.

Table 2. Results of the physical tests applied to the stone specimens.

Sample code	Apparent density, P_b (g/cm ³)	Real density, P_r (g/cm ³)	Total porosity, p (%)	Water absorption	
				By weight (%)	By volume (%)
Stone 1	2.7	2.9	7.6	0.5	1.3
Stone 2	2.7	3.0	8.7	0.7	1.8
Stone 3	2.7	2.7	1.9	0.2	0.5
Stone 4	3.0	3.1	4.8	0.1	0.4
Stone 5	2.6*	2.8	8.8	2.5*	6.5*
Stone 6	3.0	3.1	1.8	0.1	0.3

* Due to the dimensions of the stone sample, only one specimen could be prepared in accordance with the standard. The relevant results should be disregarded as they pertain to this single specimen, which also exhibited cracks.

**Figure 6.** Average capillary water absorption curves of the stone specimens.

density, real density, open porosity, and total porosity of 2.7 g/cm³, 2.9 g/cm³, 1.2%, and 6.1%, respectively. The average water absorption by weight of these limestone samples is nearly 0.5%.

Samples taken from the lead gray-colored, extremely high-strength (average uniaxial compressive strength 108.7 N/mm²) magmatic gabbro rocks found at the lower parts of the walls have an average apparent density of 3.0 g/cm³, a real density of 3.1 g/cm³, an average open porosity of 0.4%, a total porosity of 3.3% according to TS EN 1936 (TSE, 2007), and an average water absorption by weight value of 0.1%. Capillary water absorption of the specimens from both gabbro groups was negligible. Results of the physical tests and uniaxial compression test applied to the gabbro specimens are presented in Tables 1 and 2.

Bricks: Three prismatic specimens were prepared for testing from each of the three brick samples, resulting in a total of nine specimens. The uniaxial compressive strength of the specimens was determined and converted to normalized compressive strength (Table 3) according to TS EN 772-1 (TSE, 2012a). Normalized compressive strength values of the specimens prepared from the three brick samples of three different heights (40 mm/B-1, 35 mm/B-2, and 50 mm/B-3) used in the building are 10.5, 14.5, and 4.3 N/mm² on average, respectively, and meet the minimum average compressive strength requirement (5.0 N/mm²) for medium-strength clay bricks specified in TS EN 771-1 (TSE, 2011).

Physical properties of the brick samples (Table 4) were determined through tests for real density, apparent density, and total and open porosity of the specimens according to TS EN 1936 (TSE, 2007), along with a water absorption test (Table 4). Brick specimens' capillary water absorption coefficients (Table 5) were determined in line with TS EN 15801 (TSE, 2010), using three prismatic specimens prepared from each sample, resulting in a total of nine specimens.

Brick specimens were detected to have an average apparent density of 1.8 g/cm³, a real density of 2.8 g/cm³, a total porosity of 35%, an open porosity of 29% according to TS EN 1936 (TSE, 2007) a water absorption ratio by weight of 17%, an average capillary water absorption coefficient of 0.1684 kg/(m²·√sec) according to TS EN 15801 (TSE, 2010) and it ranged from 0.0643 to 0.3680 kg/(m²·√sec). The capillary water absorption curves given in Figure 7 were utilized to determine the capillary water absorption coefficient.

Mortars: Of the mortar samples brought to the laboratory, prismatic specimens could only be obtained from sample no. 3. Prepared samples were subjected to a uniaxial compression test. The compressive strengths (N/mm²) of the specimens are shown in Table 6.

Table 3. Uniaxial compressive strength of the brick specimens.

Sample code	Uniaxial compressive strength (N/mm ²)		Normalized uniaxial compressive strength (N/mm ²)	
	Value for each specimen	Average value	Value for each specimen	Average value
Brick 1				
height (thickness): 40 mm	19.1	16.9±1.7	11.9	10.5±1.1
	16.4		10.1	
	15.1		9.4	
Brick 2				
height (thickness): 35 mm	21.5	23.9±1.7	13.3	14.5±0.8
	25.2		15.0	
	25.2		15.2	
Brick 3				
height (thickness): 50 mm	8.3	6.7±1.3	5.3	4.3±0.8
	6.5		4.2	
	5.2		3.3	

Table 4. Results of the physical tests applied to the brick specimens.

Sample code	Apparent density, Pb (g/cm ³)	Real density, Pr (g/cm ³)	Total porosity, p (%)	Water absorption	
				By weight (%)	By volume (%)
Brick 1	1.8	2.8	35.9	16	29
Brick 2	1.8	2.7	31.5	16	28
Brick 3	1.7	2.8	38.5	18	31

Table 5. Capillary water absorption coefficients of the brick specimens.

Sample code	Capillary water absorption coefficient (kg/(m ² ·√sn))	Average capillary water absorption coefficient (kg/(m ² ·√sn))
Brick 1	0.0628	0.0643
	0.0729	
	0.0572	
Brick 2	0.0749	0.0730
	0.0769	
	0.0672	
Brick 3	0.3705	0.3680
	0.3869	
	0.3467	

Table 6. Uniaxial compressive strength of the mortar specimens.

Sample code	Uniaxial compressive strength (N/mm ²)	Average uniaxial compressive strength (N/mm ²)
Mortar 3	0.9	1.2±0.5
	1.9	
	0.9	

The point load strength index (Is (50)) in TS 699 (TSE, 2009) was determined by the point load test applied to the mortar samples with suitable geometry and dimensions. According to the literature, the ratio between the point

load strength index and uniaxial compressive strength (strength conversion factor) of historical mortars varies between 6 and 10 (Polat Pekmezci, 2012; Polat Pekmezci & Ersen, 2010; Gürdal et al., 2011). In a study on lime mortars, the relationship between uniaxial compressive strength and point load strength index was investigated and the strength conversion factor was determined as 8 (Ulukaya et al., 2012). Using this value, the point load test results were converted to uniaxial compressive strength, and the results are given in Table 7. Tests for the determination of physical properties could only be applied to prismatic samples obtained from sample 3. The results of these tests are given in Table 8.

Table 7. Point load test results of the mortar specimens.

Sample code	Corrected point load strength index, $I_{s(50)}$ (N/mm ²)	Converted uniaxial compressive strength (N/mm ²)	Average converted uniaxial compressive strength (N/mm ²)
Mortar 1	0.20	1.6	1.7±0.1
	0.23	1.9	
Mortar 2	0.34	2.7	2.0±0.8
	0.29	2.3	
	0.12	0.9	
Mortar 3	0.07	0.5	0.9±0.7
	0.23	1.8	
	0.04	0.3	

Table 8. Results of physical tests applied to the mortar specimens.

Sample code	Apparent density, P_b (g/cm ³)	Real density, P_r (g/cm ³)	Total porosity, p (%)	Water absorption	
				By weight (%)	By volume (%)
Mortar 3	1.7	2.6	33.6	19	32

Table 9. Capillary water absorption coefficients of mortars.

Sample code	Capillary water absorption coefficient (kg/(m ² ·√sec))	Average capillary water absorption coefficient (kg/(m ² ·√sec))
Mortar 3	0.3799	0.3359
	0.3319	
	0.2960	

The capillary water absorption coefficients of the mortar samples were determined according to TS EN 15801 (TSE, 2010). Three specimens could be prepared only from mortar sample no. 3 based on the dimensions and geometrical qualities specified in the standard. The capillary water absorption coefficients of those three prismatic samples are presented in Table 9. The capillary water absorption curve given in Figure 8 is used to determine the capillary water absorption coefficient.

Acid loss analysis was performed to roughly estimate the binder:siliceous aggregate ratio of the mortar samples taken from different locations (Figure 5). Specimens weighing at least 50 g were taken from the mortar samples, pulverized, treated with 10% hydrochloric acid, and mixed for 60 minutes, and the weight loss ratio of each after acid treatment was determined by filtering them through filter paper. According to the results given in Table 10, the binder:aggregate ratio varies between 1:2 and 1:4. The aggregates retained after acid treatment were subjected to sieve analysis to determine their grain size distributions, as presented with the granulometry curves in Figure

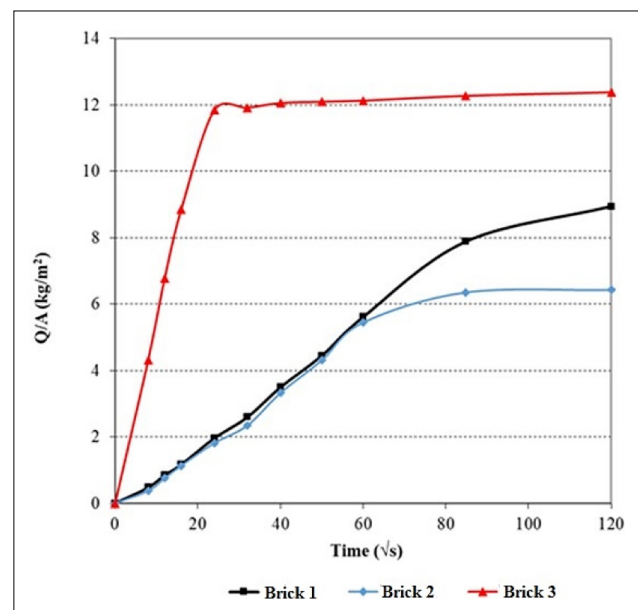


Figure 7. Average capillary water absorption curves of the brick specimens.

9. Accordingly, the maximum aggregate grain size was determined to be 8 mm for all mortar samples.

Weight losses of the mortars against temperature changes were investigated by loss on ignition analysis to determine the ignition loss at 200–600 °C which represents the output of structurally bound water (H₂O), and the ignition loss above 600 °C which represents the release of carbon dioxide (CO₂) as a result of the calcination of carbonated lime, since the hydraulic properties of the mortars are

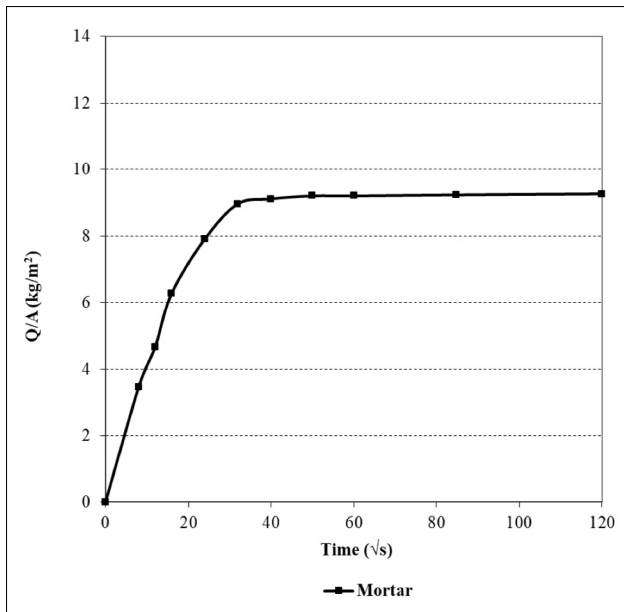


Figure 8. Average capillary water absorption curve of the mortar specimens.

Table 10. Acid loss percentages and roughly determined binder-aggregate ratios of the mortar specimens.

Sample no.	Acid Loss (%)	Binder:Aggregate
Mortar 1	20.3	1:4
	20.0	1:4
Mortar 2	39.1	1:2
	33.5	1:2
Mortar 3	23.4	1:3
	25.3	1:3

evaluated according to the ratio of lost carbon dioxide and water percentages ($\text{CO}_2/\text{H}_2\text{O}$). If this ratio is less than 10, it is accepted that the mortars show hydraulic properties, and if it is between 10 and 35, it is assumed that they do not show hydraulic properties (Moropoulou et al., 1995a; Moropoulou et al., 1995b; Bakolas et al., 1995; Bakolas et al., 1998; Moropoulou et al., 1999; Moropoulou et al., 2000). Accordingly, the ratio of lost carbon dioxide and water percentages ($\text{CO}_2/\text{H}_2\text{O}$) of the examined specimens being less than 10 indicates that the sampled mortars have hydraulic properties (Table 11).

Recommendation for consolidation mortar

The laboratory examinations indicated that the three sampled mortars were lime mortars showing hydraulic properties with a maximum aggregate grain size of 8 mm and having lime:aggregate ratios (calculated roughly through the acid loss analysis) between 1:2 and 1:4 (the average corresponds to 1:3). Taking into account these characteristics, an average mortar mixing ratio that is

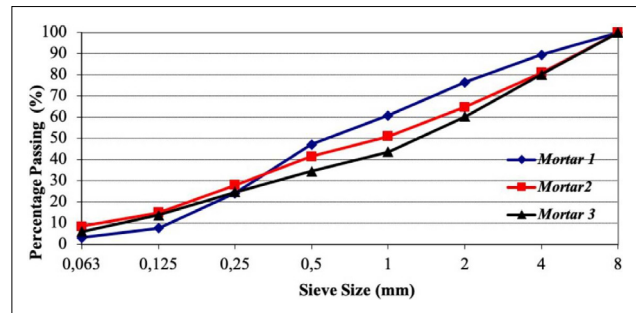


Figure 9. Grain size distribution of the aggregates.

Table 11. Ignition loss results in mortar specimens.

Sample no.	Loss on Ignition		$\text{CO}_2/\text{H}_2\text{O}$
	200-600 °C	<600 °C	
Mortar 1	2.4	5.4	2.2
	2.8	5.9	2.1
Mortar 2	3.0	17.0	5.6
	3.3	18.9	5.7
Mortar 3	2.7	13.8	5.1
	3.0	15.7	5.3

considered suitable for use in the consolidation of the structure is given in Table 12. In the mixture, silica-based aggregate with a maximum grain size of 8 mm and natural hydraulic lime in NHL 3.5 class in accordance with TS EN 459-1 (TSE, 2012b) or alternatively lime putty (air lime) with pozzolan as the binder, are recommended to be used, and the grain distribution of the aggregates is suggested to be in accordance with the granulometry curve in Figure 10.

FIELDWORK

Conservation interventions were started in 2018 on the basis of the findings obtained as a result of the examinations and determinations made on the wall remains in the archaeological area and the material analyses carried out in the laboratory.

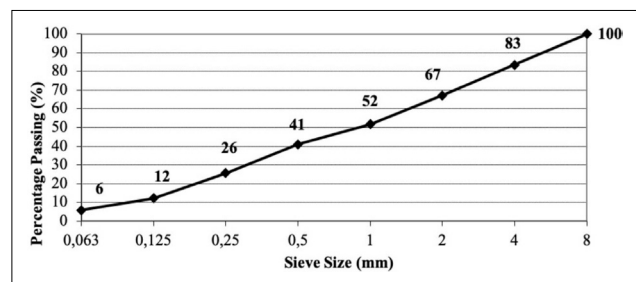


Figure 10. Suggested granulometry values for aggregate to be used in consolidation mortar.

Consolidation of the walls

Condition of the walls: In September 2018, partial wall removal work started in the regions where the well foundations correspond. The removed wall stones were numbered and properly kept in a storage area (Figure 11). A scaffold was erected for the work related to well foundations. The wells were dug by hand.

Although the walls were being supported with sandbags against rain, it was predicted that precipitation would pose a threat in winter conditions, especially to the weak masses containing soil, rubble, and broken terracotta fragments (Figure 12) present between some stone walls at different elevations.

Preparation and application of consolidation mortars:

For the consolidation of the walls in the excavation area, a mortar mixture was proposed based on the material analyses report, and the materials to be used in this mixture were requested to be supplied from the contractor company. A sample from the tuff stone fragments, which were supplied by the contractor company from Nevşehir region and recommended for use in the mortar mix as a pozzolan, was taken to the Construction Materials Laboratory of the Faculty of Civil Engineering at Yıldız Technical University to perform pozzolanic activity tests.

XRD analysis was performed using a GNR brand APD 2000-PRO model device, and the minerals contained in the powdered tuff specimen ($d < 63 \mu\text{m}$) were determined qualitatively. According to the XRD analysis, quartz, plagioclase (anorthite), calcite, augite, and hematite minerals were observed in the diffraction patterns of the examined material (Figure 13). No distinct amorphous phase could be detected due to the XRD analysis of the examined sample. In order to determine the chemical composition of the material under investigation, XRF (X-Ray Fluorescence Spectrometry) analysis was performed on powder samples ($d < 63 \mu\text{m}$) prepared in the laboratory using a Bruker brand S8 Tiger model device. The results

are given in Table 13 as the elemental components of the sample, in terms of oxides and their percentage by weight. Accordingly, the sample examined contains mainly silicon and calcium and, secondarily, aluminum, magnesium, and iron elements. The total of “ $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ ” by weight included in the material is 48.80%. This value does



Figure 12. Weak masses containing soil, rubble, and broken terracotta fragments that are prone to erosion by rain.



Figure 11. Numbered wall stones.

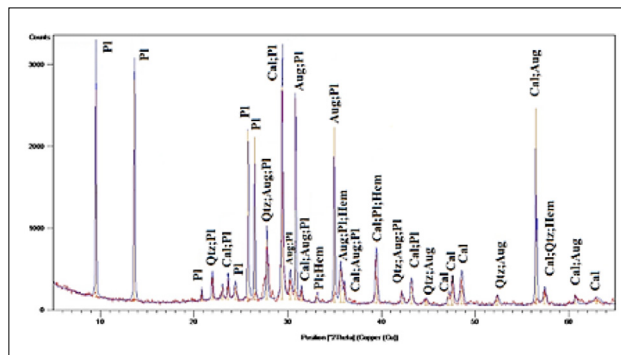


Figure 13. XRD diffraction patterns of the examined sample (Aug: Augite; Cal: Calcite; Hem: Hematite; Pl: Plagioclase; Qtz: Quartz).

not meet the minimum limit value of 70%, which is one of the conditions specified in TS 25 (TSE, 2008) and required for the material to be qualified as natural pozzolan.

Within the scope of the test conducted according to TS 25, the compressive strength of three mortar specimens prepared in 4x4x16 cm molds with a mixture of air lime, sand, and the tuff sample to be tested was determined. Due to the TS 25 standard, if the compressive strength of the lime mortars prepared with the material tested is 4 MPa and above, the tested material is accepted as pozzolan. Since the compressive strengths of the tuff specimens are below 4 MPa, the tuff sample in question is not accepted as pozzolan according to TS 25.

When the results of the mineralogical analysis (XRD), chemical analysis (XRF), and strength tests are taken into account, the examined material cannot be qualified as a natural pozzolan for cement and concrete as specified in TS 25. However, according to the results of the Frattini test, which is based on the chemical titration method and performed in accordance with TS EN 196-5 (TSE, 2012c), it was determined that the material in question showed low pozzolanic activity. In addition, blast furnace slag and fly ash, which are widely used artificial pozzolans, were also analyzed in order to compare the pozzolanic activity of the material under investigation. The results showed that the pozzolanic activity of the examined tuff fragments was lower than that of blast furnace slag and fly ash (Figure 14). In order to increase the pozzolanic effect, and thus the lime mortar strength, the contractor was advised to reduce the grain size below 63 or 75 microns by grinding the tuff fragments.

During the site visit in December 2018, a consolidation mortar that complies with the granulometry determined by the analyses was prepared with the materials requested from the contractor, such as sieves, lime, aggregates, and tuff fragments ground into powder. This mixture, which is applied to a small section of a wall, contains air lime (lime putty) as the binder, river sand as the aggregate, and tuff stone (recommended by the contractor) powder as the pozzolan, and acrylic dispersion (Primal AC33 equivalent) as an admixture. As in the original mortar, the mortar was prepared to gain hydraulic properties by using pozzolan and air lime. However, it was seen that the mortar applied did not provide sufficient pre-hardening and strength after a week. In order to increase the strength, two different trial mortars with hybrid binders were prepared by mixing natural hydraulic lime (NHL 3.5) which was indicated in the material analyses report, with air lime in certain

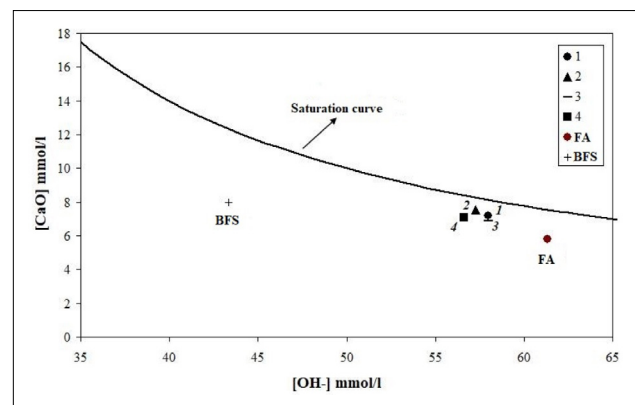


Figure 14. Frattini test results of four specimens from the same tuff sample (1, 2, 3, and 4), along with a blast furnace slag (BFS) specimen and a fly ash (FA) specimen. The plots of the four tuff specimens are situated near the saturation curve, indicating that they exhibit low pozzolanic activity.

proportions. These mortars, which also contain river sand, tuff fragments, and tuff dust, were applied next to the previously applied mortar (Figure 15).

Mortars containing only NHL as the binder were also prepared, but it was observed that the workability of the mortars with the hybrid binder was better than that of the mortars containing only NHL as the binder. Two weeks after the application, it was realized that the strength of the mortars with hybrid binders, whose workability was also high, was at a satisfactory level. Therefore, a mortar with a hybrid binder composed of lime putty and NHL in equal proportions was decided to be used.

The weak masses containing soil, rubble, and broken terracotta fragments shown in Figure 16 that are prone to getting damaged by precipitation were reinforced by coating them with a hydraulic lime mortar of higher strength than the one designated for pointing the walls (Figure 15). NHL 5 type natural hydraulic lime and river sand were used for this purpose, in line with the proportions given in Table 12.

Injection application: Inspections carried out on the site gave rise to the thought that an injection application was also necessary for the consolidation of the walls. Thereupon, simple tests were carried out to determine the ingredients of an efficient injection grout. For this purpose, first of all, various blends intended for injection with different water, aggregate, binder, and admixture proportions were mixed at the worksite. Then tests were carried out with these grouts prepared using NHL, limestone powder (under 100 microns)

Table 12. The ratios of the components of the recommended consolidation mortar by weight.

Lime	Aggregate	Water
1	3	The amount of water should be determined in accordance with the flow values indicated in TS EN 1015-2 (TSE 2000a), and by preliminary tests to be carried out in accordance with TS EN 1015-3 (TSE 2000b).

Table 13. Chemical composition of the tuff sample in terms of oxides.

Constituent	Wt %
SiO ₂	30.10
Al ₂ O ₃	9.44
Fe ₂ O ₃	9.26
MgO	6.73
CaO	25.06
Na ₂ O	1.68
K ₂ O	1.18
TiO ₂	1.21
P ₂ O ₅	0.29
SO ₃	0.21
BaO	0.04
CuO	0.11
NiO	0.02
MnO	0.15
SrO	0.06
Cr ₂ O ₃	0.04
ZnO	0.07
ZrO ₂	0.03
Cl	0.05
F	0.20
Ignition loss (1050°C/3 hours)	14.02

and tuff powder (under 75 microns). The grout mixtures were poured into 60-mL injectors standing vertically and also into small cups. It was observed at the end of one week that samples containing equal amounts of tuff powder and

**Figure 15.** Previously applied lime mortar with a lighter color and fresh trial mortars with the hybrid binder (they can be distinguished by the color differences between them) applied to a small section infested by algae.

limestone powder took a longer time to set, shrank, and bled more compared to those containing only limestone powder as the aggregate (Figure 17). These results suggested that tuff powder did not sufficiently react with air lime, which is a non-hydraulic component of NHL, and did not contribute enough to the setting process. Hence, the results were considered compatible with the results of the pozzolanic activity tests applied. With respect to this, the tuff powder was decided not to be used in the next trial blends prepared at the worksite. In this context, trial blends containing NHL, limestone powder, water, and acrylic dispersion (Primal AC33 equivalent) were prepared. To be able to ensure sufficient fluidity by using the minimum amount of water, the amount of water in each blend prepared was reduced compared to the amount used

**Figure 16.** A weak mass consolidated by covering it with a lime mortar containing NHL 5.



Figure 17. Injectors and cups used to monitor the bleeding water, shrinkage amount, and setting status of the trial grouts prepared at the worksite for injection.

Table 14. Grout composition in parts by volume.

Natural Hydraulic Lime	Limestone Powder	Water	Acrylic Dispersion
1	1	1.25	0.1

in the previous one. The composition shown in Table 14 was chosen as the most suitable grout mixture for consolidation and applied to the walls, starting from the bottom parts (Figure 18).

Removal of Algae

As a cleaning proposal against algae formation on the walls (Figure 15; Figure 18; Figure 19) was required, it was suggested that algae removal should start after the consolidation of the walls was completed and the rainy weather passed away, and initially mechanical cleaning was advised to be done with plastic brushes and water. Following this step, brushing with a benzalkonium chloride containing biocide such as Preventol RI 80 or Preventol RI 50, which are commonly used for biologically infested archaeological and historic masonry materials (Macchia et al., 2022; Antonelli et al., 2024; Berti et al., 2024), and then rinsing with water was recommended. This procedure was applied first to a small area, and its effectiveness was monitored for a certain period. Since success was achieved, it was then applied to the zones infested by algae.

Conservation of Earthenware Pipe and Terracotta Sarcophagus

The excavated earthenware pipe and terracotta sarcophagus fragments (Figure 20) were cleaned and assembled in the workshop set up on the worksite to be displayed in situ. The fragments were assembled in sandboxes using epoxy resin (Figure 21). To remove loose deposits, water and plastic brushes were used, while concretions were removed using scalpels and dental instruments.



Figure 18. Grout application through injection on a wall infested with algae.



Figure 19. Algae formation on the horizontal surfaces of the walls.

CONCLUSION

Following the rescue excavation, mortar, brick, and stone samples were obtained to determine the properties of the construction materials that constitute the architectural remains to be conserved. On-site inspections and laboratory examinations showed that two different types of natural stones were used throughout the building, namely limestones, including dolomitic limestone, and igneous rocks, including microlithic gabbro-type basic rocks, that



Figure 20. Earthenware pipes (on the left) and a terracotta sarcophagus (on the right) broken into pieces.



Figure 21. Earthenware pipe fragments that were cleaned and assembled in the workshop set up at the worksite.

were in good condition in terms of preservation. Laboratory work also indicated that the bricks were sound since they meet the minimum strength requirements for medium strength clay bricks. However, the joints of the stones and bricks and the core of the walls became widely empty due to the deterioration of the original mortars. Therefore, the first step of the conservation work was decided to be the consolidation of the walls since the work coincided with the winter season, and since precipitation has become the leading factor that threatens the wall remains by weakening



Figure 22. General view of the site after the earthquake.

the remaining mortars. Supports created with sandbags temporarily protected the walls before the consolidation was performed.

A lime mortar for consolidation was prepared in accordance with the results obtained from the laboratory work applied to the original mortar samples. Based on the material analyses, trials were made on the site to optimize the mortar blend suitable for consolidation in terms of color, texture, workability, and strength. Since the pozzolanic activity tests performed on the tuff obtained from Nevşehir region revealed that this material showed low pozzolanic activity, it was concluded that using this material together with air lime would not be enough to achieve the desired success. The trials carried out on the site with tuff-bearing mortars also supported this view. For that reason, it was deemed appropriate to use the tuff together with natural hydraulic lime and, to increase its pozzolanic effect, to use it after it was ground very finely. In this context, pulverized tuff was used as a color component rather than as a natural pozzolan. The mortar applied consisted of natural hydraulic lime (NHL 3.5), air lime, blended in accordance with the binder:aggregate ratio specified in the material analyses report, river sand with a small amount of tuff dust compatible with the granulometry specified in the same report, and acrylic admixture.

The results obtained from the inspections carried out on the site gave rise to the thought that an injection application was also required for the consolidation of the walls. In this regard, an injection grout was designed by preparing various blends with different water, aggregate, binder, and admixture proportions and subjected to simple tests at the worksite. In this context, injectors and cups were used to monitor the bleeding water, shrinkage amount, and setting status of the trial mortar blends containing NHL, limestone powder, water, and acrylic dispersion (Primal AC33 equivalent) for injection. The grout mixture considered most suitable for consolidation was applied to the walls, starting from the bottom parts.

Furthermore, prognosticating that precipitation would pose a threat to the weak masses containing soil, rubble, and broken terracotta fragments present at different elevations, these masses were reinforced by coating them with a hydraulic lime mortar of higher strength than the one designated for pointing the stone walls.

Interventions to control the biological activity were also carried out as part of the conservation of the walls. In this respect, a biocide containing benzalkonium chloride succeeded in the removal and prevention of the algae, though dampness should be controlled under the glass platform and cleaning operations should be repeated if infestation occurs again. Moreover, assembly and cleaning works performed on the earthenware pipes and terracotta sarcophagus fragments were carried out successfully under the conditions available at the worksite.

It should finally be noted that, after the earthquake, the site is not allowed to be visited or inspected yet; however, according to the view from outside the archaeological site, the consolidated remains seem sound and undamaged by the earthquake (Figure 22).

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REFERENCES

- Adams, R. D., & Barazangi, M. (1984). Seismotectonics and seismology in the Arab region: A brief summary and future plans. *Bulletin of the Seismological Society of America*, 74(3), 1011–30. <https://doi.org/10.1785/BSSA0740031011>
- Antonelli, F., Iovine, S., Perasso, C. S., Macro, N., Gioventù, E., Capasso, F. E., & Bartolini, M. (2024). Essential oils and essential oil-based products compared to chemical biocides against microbial patinas on stone cultural heritage. *Coatings*, 14(12), 1546. <https://doi.org/10.3390/coatings14121546>
- Bakolas, A., Biscontin, G., Contardi, V., Franceschi, E., Moropoulou, A., Palazzi, D., & Zendri, E. (1995). Thermoanalytical research on traditional mortars in Venice. *Thermochimica Acta*, 269–70, 817–28. [https://doi.org/10.1016/0040-6031\(95\)02574-X](https://doi.org/10.1016/0040-6031(95)02574-X)
- Bakolas, A., Biscontin, G., Moropoulou, A., & Zendria, E. (1998). Characterization of structural Byzantine mortars by thermogravimetric analysis. *Thermochimica Acta*, 321(1–2), 151–60. [https://doi.org/10.1016/S0040-6031\(98\)00454-7](https://doi.org/10.1016/S0040-6031(98)00454-7)
- Berti, L., Arfelli, F., Villa, F., Cappitelli, F., Gulotta, D., Ciacchi, L., Bernardi, E., Vassura, I., Passarini, F., Napoli, S., & Goidanich, S. (2024). LCA as a complementary tool for the evaluation of biocolonization management: The case of Palazzo Rocca Costaguta. *Heritage*, 7(12), 6871–90. <https://doi.org/10.3390/heritage7120318>
- Beyen, K., Erdik, M., Mazmanoğlu, C., & Ekmekçioğlu, Z. (2003). The seismic activity of Antakya from past to present and the evaluation of what needs to be done in the light of an international conference [Antakya'nın geçmişten günümüze sismik aktivitesi ve yapılması gerekenlerin bir uluslararası konferansın ışığında değerlendirilmesi]. *Turkish Engineering News [Turk Muhendislik Haberleri]*, 423, 51–3. https://eski.imo.org.tr/resimler/dosya_ekler/2342e-1b8ee9d659_ek.pdf?dergi=172
- Brown, E. T. (1981). *Rock characterization, testing and monitoring: ISRM suggested methods*. Pergamon Press.
- Chala, E. T., & Rao, K. S. (2021). Evaluation of weathered rock mass strength and deformation using weathering indices. *IOP Conference Series Earth and Environmental Science*, 833, 012194. <https://doi.org/10.1088/1755-1315/833/1/012194>
- Gürdal, E., Altaş, K. G., & Özgünler, S. A. (2011). Investigation of the characteristics of the horasan mortars used in the early Byzantine period religious structures located in Istanbul [İstanbul'da bulunan Erken Bizans dönemi dini yapılarında kullanılan horasan harçların özelliklerinin incelenmesi]. *Foundation Restoration Annual [Vakıf Restorasyon Yıllığı]*, 2, 63–72.
- Macchia, A., Strangis, R., De Angelis, S., Cersosimo, M., Docci, A., Ricca, M., Gabriele, B., Mancuso, R., & La Russa, M. F. (2022). Deep eutectic solvents (DESs): Preliminary results for their use such as biocides in the building cultural heritage. *Materials*, 15(11), 4005. <https://doi.org/10.3390/ma15114005>
- Moropoulou, A., Bakolas, A., Michailidis, P., Chronopoulos, M., & Spanos, Ch. (1995b). Traditional technologies in Crete providing mortars with effective mechanical properties. *Transactions on The Built Environment*, 15, 151–61.
- Moropoulou, A., Bakolas, A., & Bisbikou, K. (1995a). Characterization of ancient, Byzantine and later historic mortars by thermal and X-ray diffraction techniques. *Thermochimica Acta*, 269–70, 779–95.

- [https://doi.org/10.1016/0040-6031\(95\)02571-5](https://doi.org/10.1016/0040-6031(95)02571-5)
- Moropoulou, A., Bakolas, A., & Bisbikou, K. (2000). Investigation of the technology of historic mortars. *Journal of Cultural Heritage*, 1(1), 45–58. [https://doi.org/10.1016/S1296-2074\(99\)00118-1](https://doi.org/10.1016/S1296-2074(99)00118-1)
- Moropoulou, A., Bakolas, A., Moundoulas, P., & Cakmak, A. S. (1999). Compatible restoration mortars for Hagia Sophia earthquake protection. *Transactions on the Built Environment*, 41, 521–31.
- Pamir, H., & Sezgin, N. (2016). The sundial and convivium scene on the mosaic from the rescue excavation in a late antique house of Antioch. *Adalya*, 19, 247–80. <https://dergipark.org.tr/en/pub/adalya/issue/54568/743807>
- Pekmezci, P. I. (2012). *Characterization of mortars used in some historical structures in the Çukurova region (Cilicia) and recommendations for repair mortars [Çukurova bölgesindeki (Kilikya) bazı tarihi yapılar-da kullanılan harçların karakterizasyonu ve onarım harçları için öneriler]* [PhD dissertation]. Istanbul Technical University.
- Pekmezci, P. I., & Ersen, A. (2010). Characterization of Roman mortars and plasters in Tarsus (Cilicia–Turkey). In J. Válek, C. Groot, & J. J. Hughes (Eds.), *2nd Conference on Historic Mortars – HMC2010 and RILEM TC 203-RHM Final Workshop* (pp. 317–24). RILEM Publications SARL.
- T.C. Hatay Valiliği. (2019). *The city of all times: Hatay [Tüm zamanların şehri: Hatay]*. Retrieved Sep 10, 2025, from <http://www.hatay.gov.tr/hatay-tarihine-genel-bakis>
- TSE (Turkish Standards Institution). (2000a). *Methods of test for mortar for masonry – Part 2: Bulk sampling of mortars and preparation of test mortars*. TS EN 1015-2.
- TSE (Turkish Standards Institution). (2000b). *Methods of test for mortar for masonry – Part 3: Determination of consistence of fresh mortar (by flow table)*. TS EN 1015-3.
- TSE (Turkish Standards Institution). (2007). *Natural stone test methods – Determination of real density and apparent density and of total and open porosity*. TS EN 1936.
- TSE (Turkish Standards Institution). (2008). *Natural pozzolan (trass) for use in cement and concrete – Definitions, requirements and conformity criteria*. TS 25.
- TSE (Turkish Standards Institution). (2009). *Natural building stones – Methods of inspection and laboratory testing*. TS 699.
- TSE (Turkish Standards Institution). (2010). *Conservation of cultural property – Test methods – Determination of water absorption by capillarity*. TS EN 15801.
- TSE (Turkish Standards Institution). (2011). *Specification for masonry units – Part 1: Clay masonry units*. TS EN 771-1.
- TSE (Turkish Standards Institution). (2012a). *Methods of test for masonry units – Part 1: Determination of compressive strength*. TS EN 772-1.
- TSE (Turkish Standards Institution). (2012b). *Building lime – Part 1: Definitions, specifications and conformity criteria*. TS EN 459-1.
- TSE (Turkish Standards Institution). (2012c). *Methods of testing cement – Part 5: Pozzolanicity test for pozzolanic cement*. TS EN 196-5.
- TSE (Turkish Standards Institution). (2013). *Natural stone test methods – Determination of uniaxial compressive strength*. TS EN 1926.
- Ulukaya, S., Yüzer, N., Selçuk, M. E., & Yıldırım, M. (2012). Investigation of the experimental methods applied in the definition of historical lime mortars [Tarihi kireç harçlarının tanımlanmasında uygulanan deney yöntemlerinin irdelenmesi]. *100 Years in Civil Engineering Technical Congress [İnşaat Mühendisliğinde 100 Yıl Teknik Kongresi]*, Türkiye, 22 - 17 November 2012, vol.1, pp.171–180.



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M G A R O N

Article

Layout configuration and occupancy in healthcare indoors: A case study in a Turkish research hospital

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ABSTRACT

Space occupancy is acknowledged as a parameter that affects communication, teamwork, and behavior patterns in healthcare settings. This research aims to understand the patterns of space occupancy in two Inpatient Units (IU) with differing indoor environments concerning configuration and morphology. In order to understand and explain the variations in patterns of occupancy, a combination of qualitative and quantitative methods is employed to assess spatial analytics metrics such as visibility, accessibility, and physical proximity. These methods are crucial in providing a comprehensive understanding of the complex relationship between space occupancy and interactions among staff in healthcare settings. The results suggest that different spatial layouts in healthcare buildings affect the patterns of space occupancy and routes preferred by healthcare staff. Even though there are differences between morphologies of the two units studied, the research found that particular segments within corridors in relation to staff-related areas like nurse rooms, nurse stations, and med-preparation rooms affected patterns of space occupancy and movement in healthcare settings. This study may give a broader understanding on the impact of layout morphologies and the configuration and allocation of programmatic elements within layouts of medical surgical units.

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INTRODUCTION

The characteristics of physical environments in healthcare settings can influence various facets of the healthcare experience, impacting physical, psychological, and even behavioral aspects in positive or negative ways (Codinhoto et al., 2009; Ulrich et al., 2008; Zhang et al., 2019). Research

shows that the design of healthcare environments may lead to several negative consequences, including medical errors, heightened stress levels, fatigue, burnout, job dissatisfaction and frequent interruptions (Coiera et al., 2002; Donchin et al., 2003; Tyson et al., 2002). Also, research indicates that healthcare settings can foster better

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outcomes, including enhanced improved communication, staff performance, and more effective interaction patterns between patients and medical staff (Cai & Zimring, 2012; Devlin & Arneill, 2003; Ulrich et al., 2008). The layout organization within healthcare environments, and the allocation of programmatic components in particular, have an impact on both staff and patient outcomes in various ways (Codinhoto et al., 2009; Lim et al., 2020; Ulrich et al., 2008). The claim is that an effective spatial arrangement enhances the operation of a healthcare facility, resulting in improved service quality and greater patient satisfaction (Hendrich, 2003; Trinkoff et al., 2005; Zhu & Shepley, 2022). At the same time, healthcare indoors can influence the healing experience of users by facilitating interactions and communication among staff as well as between staff and patients (Cai, 2012; Shepley, 2002).

There are various formulations to study the impact of layouts in healthcare environments. The research into the patterns of space occupancy which involves the presence of inhabitants in space (Gomez-Zamora et al., 2019; Tomé et al., 2015) becomes increasingly important as the specifics of occupancy are considered to influence key parameters including safety (Ampt et al., 2008; Iyendo et al., 2016; Joseph, 2006; Shepley et al., 2022), staff communication (Cai & Zimring, 2012) and healthcare-related outcomes (Lu et al., 2009; Sailer et al., 2013; Zhang et al., 2019). The related literature suggests links between space occupancy, efficiency and inhabitants' satisfaction in healthcare environments (Haron et al., 2012). The central hypothesis in these studies, which reflects a transactional perspective, is that various configurations of built environments affect behavior in space, which in turn influence the quality of services in healthcare.

In Turkey, the design and spatial planning of healthcare environments are established in accordance with national standards and guidelines published by the Ministry of Health of Turkey. These guidelines define the functional, technical and hygienic requirements of healthcare facilities, as well as determining the institutional framework of design decisions. Also, with the Ministry of Health's Inpatient Healthcare Facilities Planning Guide (2011), the current status of hospitals is clearly presented and future goals are determined (Cansever & Gökkaya, 2022). The intention with this investigation is to provide empirical support for developing improved and enhanced guidance in designing safe and efficient healthcare environments in the context of Turkish Healthcare System.

While there is research to account for the perception and evaluation of the built environment from patients' perspective in Turkish Health System (THS) (Ergenoğlu & Tanrıtanır, 2013), the current paper primarily focuses on the activities of nurses who are considered as major actors in healthcare facilities. Recognizing the key role of nurses

in delivering care, the current paper aims at providing a perspective to consider and evaluate the allocation of particular programmatic elements (nurse stations, medication room, and nurse room) and the potential impact of spatial configuration on space occupancy in the context of a research hospital. The study specifically targets corridors within inpatient units, exploring two medical-surgical units that feature distinct spatial arrangements, and highlights the contrasts and comparisons between them. The field study took place in a large-scale state hospital in Turkey, where a continuous effort is observed to increase the bed capacity through public-private-partnership model. Accordingly, with this research, the intention is to contribute to the existing literature and to develop guidance concerning the organization of inpatient units in the context of THS.

The major research questions are:

1. What are the most frequently occupied areas by nurses in medical-surgical inpatient units?
2. How do the occupancy levels differ across the indoors of medical-surgical units with varying layouts?
3. How do certain program elements, including nursing stations, medication rooms, and nurse rooms, relate to the frequently occupied areas in medical-surgical units?

BACKGROUND

The modern hospital building, indoor areas in particular, has been a frequent ground for academic investigations starting from the second half of the 20th century. In order to understand how healthcare facilities function, researchers have elaborated on the issues of safety, efficiency, and supervision. Exploring the connection between the qualities of built environments and human behavior, one strong strand within healthcare research deals with the complex relationship between the spatial layout and the occupancy and movement patterns of users in healthcare facilities which are considered to be strong program buildings (Pachilova & Sailer, 2020; Rashid, 2009).

The patterns of occupancy in space, in this context, refers to “the simultaneous existence of inhabitants against the spatial configuration of boundaries accessed by them”, whereas the movement patterns “describe the users' spatial trajectories during their interaction with the spatial setting” (Tomé et al., 2015). These two concepts, namely occupancy and movement, are strongly linked as inhabitants' activities, including walking, gathering, encountering, and interacting, generate space occupancy patterns in buildings (Gomez-Zamora et al., 2019).

There is a growing body of research on healthcare indoors to report that both positive and negative outcomes can be influenced by spatial layout and configuration in relation

to spatial occupancy (Haron et al., 2012; Ulrich et al., 2008; Weick & Sutcliffe, 2003). As the causal argument goes, the architecture of healthcare buildings influences the occupancy and movement patterns of inhabitants, which in turn affect awareness, communication, and coordination in space, which are key parameters that impact the quality of care in healthcare settings (Gharaveis et al., 2018; Pachilova & Sailer, 2015). Pachilova and Sailer (2020) studied how hospital ward design affects quality-of-care ratings. They found that the layout impacts visibility and communication for healthcare workers, emphasizing the importance of open areas for staff moving between key locations (Pachilova & Sailer, 2020).

The studies that focus on the spatial dimension of nursing practices repeatedly emphasize the key role of circulation areas in healthcare environments (Jiang & Verderber, 2017). From a particular perspective concerning wayfinding in hospitals, there is a growing body of literature to suggest that the organization of corridors influence wayfinding decisions of users (Aksoy et al., 2020). There is also other forms of research to recognize particular aspects of corridors and hallways (Allison, 2007; Edgerton et al., 2010), which may take up to 40% of the floor area in healthcare facilities (Carthey, 2008). However, to better understand the role of circulation zones in varying contexts, there is a need for more in-depth investigations. With the aim to inform the design of future healthcare spaces in the context of THS which is constantly expanding in the last decade, the current paper examines the potential impact of spatial configuration on space occupancy and assesses the allocation of particular programmatic elements within two medical surgical units including nurse stations, medication rooms, and nurse rooms.

RESEARCH DESIGN AND METHODS

Settings

The research was conducted in inpatient units within a state-owned training and research hospital. Two general surgery inpatient units (GSIU) were included based on variations within floor layouts and their availability. There is no difference in the patient characteristics of patients to be admitted to these two units, namely Case 1 and Case 2, where the nurse-to-patient ratio is 1/10 for both units. While the ratios are considered high compared to Western standards, the numbers and workload represent the situation in a typical state-owned hospital in Turkey.

The two units are located in the same building within the Hospital Campus. The layout properties, however, display certain differences at various scales. Case 1 is considered as a race-track typology with the patient rooms on the perimeter, whereas the center of the layout was equipped with service and staff-related areas. Case 2 can be regarded as an L-shaped corridor typology; the patient rooms were organized on the perimeter of the floor plan, whereas the staff-related areas were distributed within the unit (Figure 1). In Case 1, the medication preparation room, nurse station, nurse room and treatment room are in close proximity and located around the center of the unit layout, while these particular rooms are not clustered in Case 2. In Case 2, nurse station and treatment room are located at the center of the unit, whereas the medication preparation room and nurse room are set apart from the central nurse station.

There is a pool of 70 nurses to provide care in shifts for the two units. All nurses report to the same Chief Nursing Officer for the GSIU services, who follow a flexible assignment strategy. The nursing roster includes individuals ranging from interns who are currently enrolled at the College of

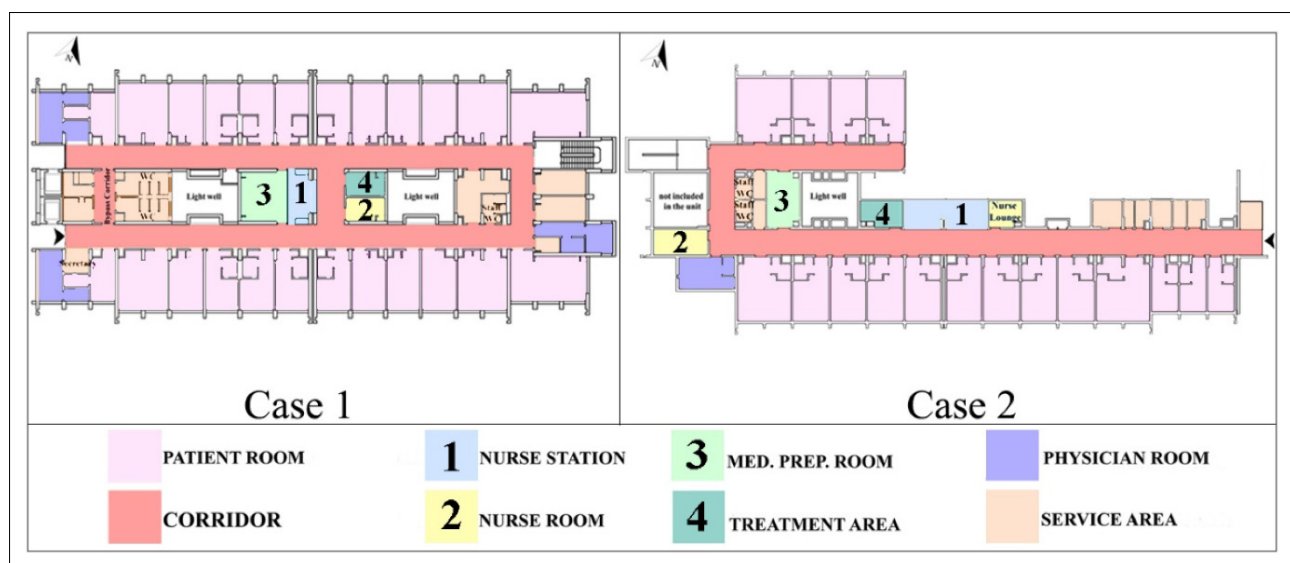


Figure 1. Schematic layouts of case studies.

Nursing of the same university to Registered Nurses with more than 20 years of experience. The same group of nurses, under the same administrative body, provide care for the patients with similar clinical characteristics, which -we presume- leaves the configuration of space as the primary variable to impact space occupancy and related parameters under focus for this research.

Methods

This study follows a mixed-method strategy including, a series of field observations, a survey and off-site techniques to analyze the layouts. Permission from the Ethics Committee of the university was granted prior to the initiation of the field research protocol at the hospital.

Observations: The primary field strategy of this research involved observations that were used to develop insights into nurses' space occupancy and movement by recording the activities of staff members during their daily routines within the two units. To understand the occupancy dynamics in the inpatient units, two types of field observations were used: Location mapping observations (LMO) and nurse activity observations (NAO). Each observation type was conducted for 10 days -mornings and afternoons- for each unit. The total number of recordings for LMO was 105 observation recordings at Case 1, and 115 observation recordings at Case 2, while the overall recordings for NAO were 51 observation sessions at Case 1, and 49 observation recordings at Case 2 (Table 1).

LMO protocol was carried out by recording the locations of occupants by taking a single tour along a pre-determined route 10-12 times a day. The route mainly followed the corridor of the units from end-to-end, and the field researcher digitally recorded the locations of the staff without entering the patient rooms. The LMO recordings included both activities and the exact locations of the nurses.

The obtained plan with LMO recordings was analyzed in detail with a specialized plan analyzer plugin, which is built specially for this task by using Rhino 3D API and C# programming language. The intention was to develop a unified form of representation for both types of observations and space syntax analysis to allow better comparison for the floor plans studied. To create a template for analysis, first, the layout that included the observation data was imported into the Rhino software. The unit layouts were overlapped with a 60 cm by 60 cm cell grid, which generated the

template for analysis (Figure 2). Second, a plan analyzer plugin was employed to detect staff location recordings on layouts through circle shapes. Next, upon detection process, the cells of the grid automatically generated the counts of the categorized staff traces on the layout.

The layout grid, then, was converted into a colored heat map based on the results from the plan analyzer plugin. The extracted heat maps -which represented the observation data for each case - were organized through 5 colors - red to blue- where red cells displayed the most occupied areas and blue cells represented relatively less occupied areas on the floor plan (Figure 3). As presented in the findings section, the data set was also analyzed by calculating the ratio of accumulation of areas with respect to the total area of the floor plan.

Each NAO entry, on the other hand, included movement records of a single nurse for ten minutes, conducted five to seven times a day. For each NAO recording entry, a different nurse was inconspicuously followed (Figure 4). Data collected from both NAO and LMO were then gathered and tabulated on floor plans to understand the accumulation of space occupancy in spatial layout.

Space Syntax: Space syntax analysis was used to better understand the configuration in the inpatient units. Using the space syntax method, the floor plan of the inpatient unit was analyzed via visual graph analysis (VGA), which examines the availability and accessibility of space visually throughout the entire spatial system, considering all edges. The same grid of 60cm by 60cm is employed in processing the syntax analysis, which helps to identify particular zones with high levels of visibility and/or integration within the two case studies. The graphics from the syntax analysis provided a ground for understanding the highly visible areas in the units, which in turn helped us to discuss the results from the two types of observation mappings.

Survey: The field strategies included a survey aimed at better understanding the daily routines concerning care delivery and perceptions of nurses in units. The survey was designed as a paper-based questionnaire with multiple-choice and open-ended questions, along with a drawing task that asked the nurses to draw their most frequently used routes in the units. The intention of the survey was to assess the perspectives of nurse practitioners at units in relation to the research agenda. The survey part of the research protocol

Table 1. The total number of observation recordings

Number of Observation Records	Location Mapping Observation (LMO)			Nurse Activity Observation (NAO)		
	AM	PM	Total Records	AM	PM	Total Records
Case 1	51	54	105	25	26	51
Case 2	59	56	115	24	25	49

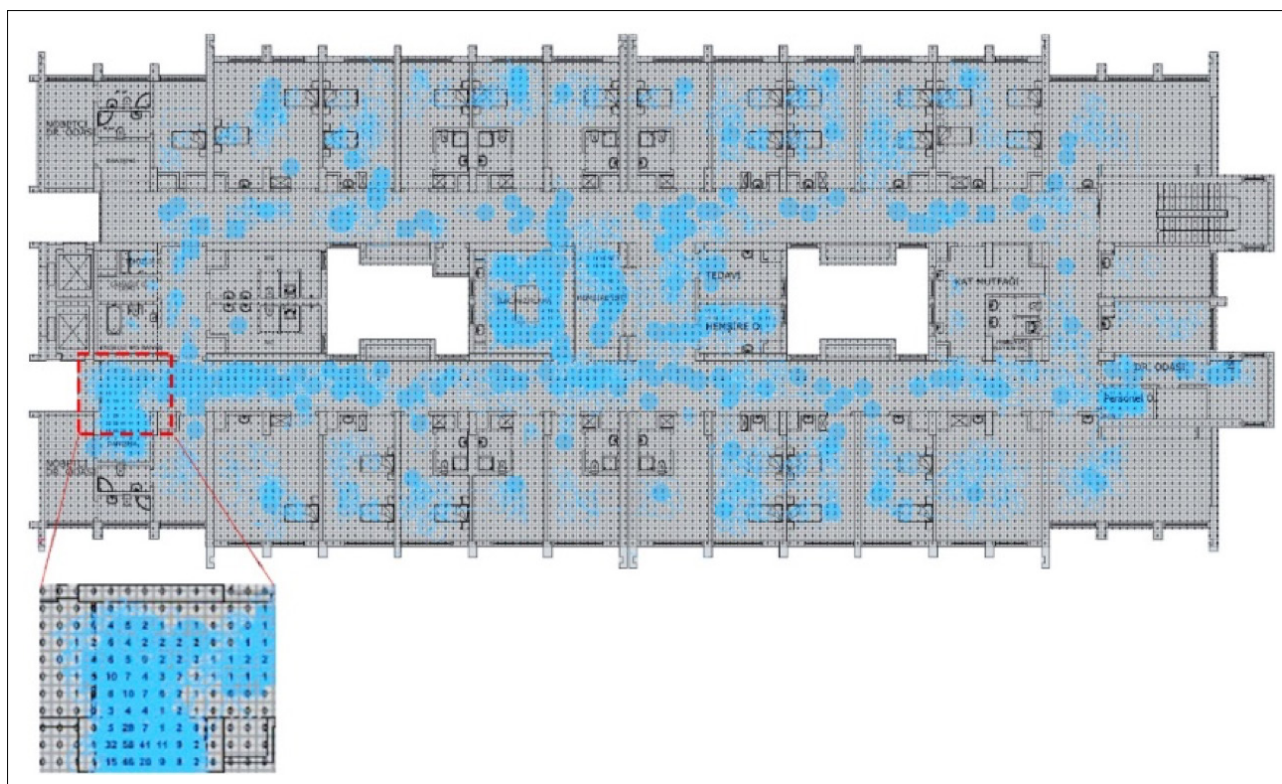


Figure 2. Detecting counts of the categorized staff traces.

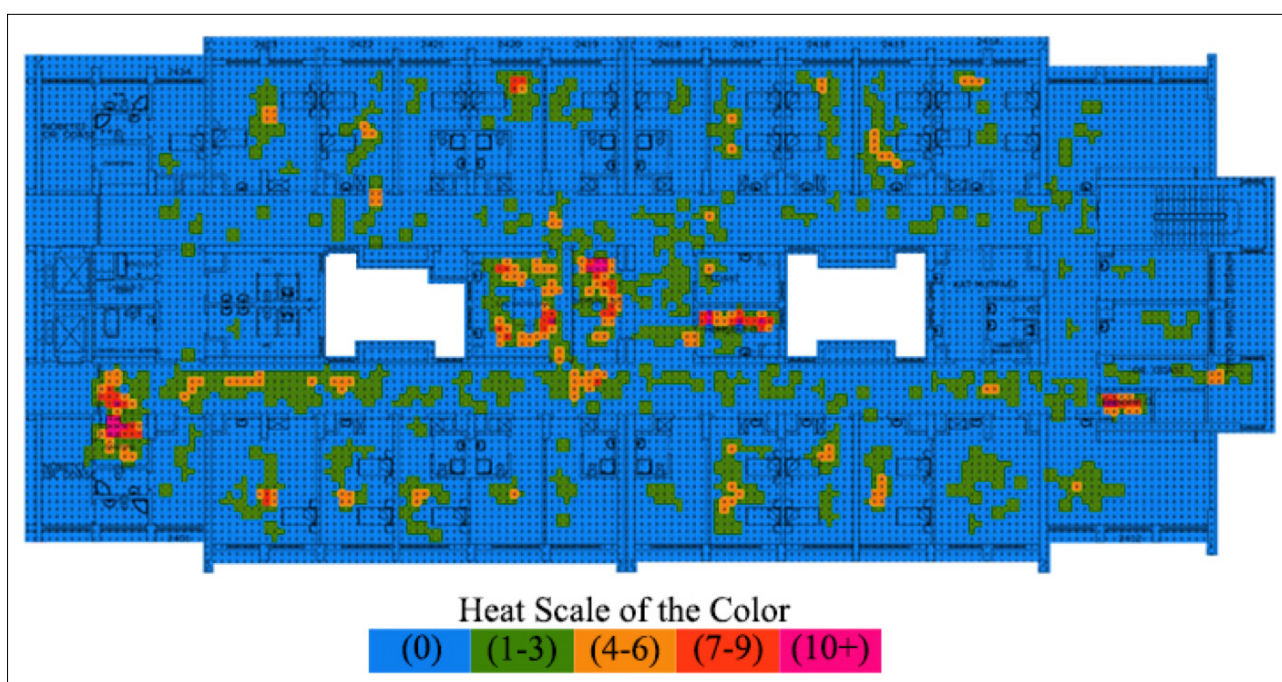


Figure 3. Extracted heat map.

did not undergo validity or reliability processes. However, two experienced nurses, one being an academic and the other a practitioner, acted as consultants in generating the questions and parts of the survey. Also, a pilot study was conducted to test the survey administration process on-site.

The survey was conducted with 29 nurses (11 nurses in Case 1, 18 nurses in Case 2), and it took no more than ten minutes for each participant. The participant nurses were asked to respond to the questions with regard to the unit they were assigned to on the day of survey

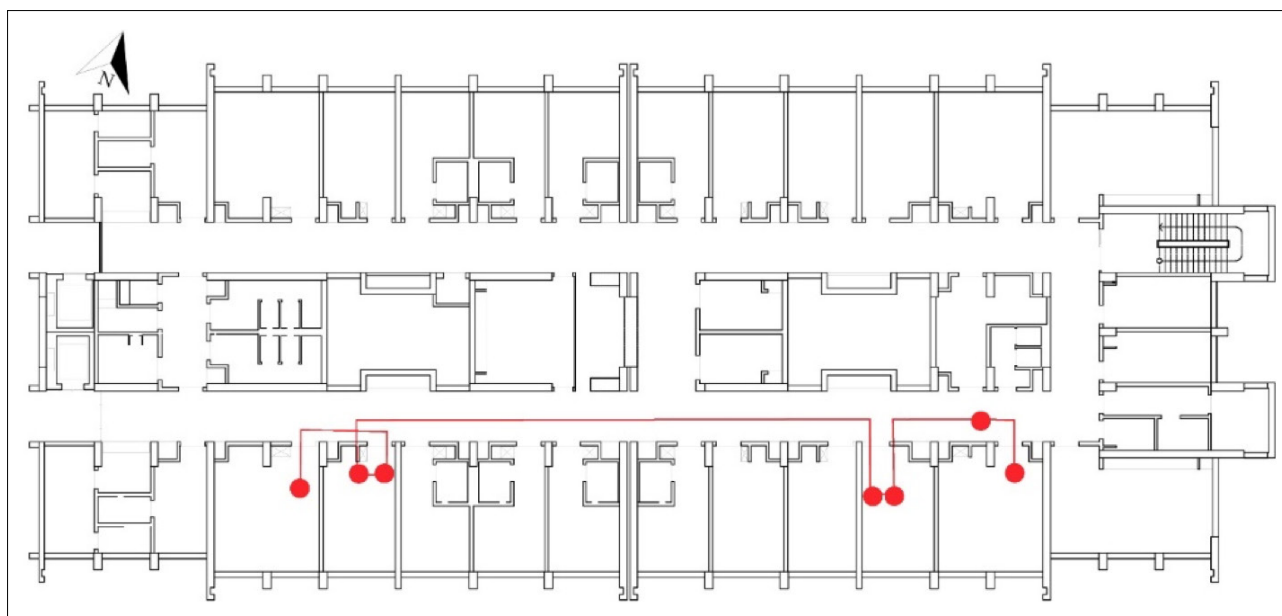


Figure 4. Staff traces of nurse activity mapping in a one session at Case 1.

administration. The survey included four main parts to gather relevant information at sites. The first part contains profile questions, including age, job description, gender, and experience levels. The second part involves questions to understand nurses' perceptions about their levels of communication and access to understanding interaction networks and location and the frequency of interactions between colleagues. The third part of the survey is designed to understand the effects of the spatial layout of the inpatient units on nurses' space occupancy. The last part of the survey is the drawing task, which generated self-reports on staff behavior in the respective units. The drawing task asked staff to mark their typical routes on a layout to understand the frequently occupied areas from nurses' perspective.

FINDINGS

Observations

Location Mapping Observation (LMO): The data emerging from the location mapping was initially transferred onto unit layouts to better understand the occupancy patterns during shifts. Figure 5, below, visualizes the location records for both cases. Although there are morphological and configurational differences between the two units, similar functional zones were observed to be frequently used by nurses in each unit, including particular segments of the corridors and also staff-related areas, including medication preparation rooms, nurse rooms and nurse stations. Case 1 shows that the intersection of the unit entrance and in front of the unit secretary hosts an accumulation due to administrative activities involving patients and their families. In Case 1, the graphic suggested a difference in the

patterns of occupancy between the southern and northern corridors of the unit (Figure 5).

Apart from patient rooms, the three components of the functional program within the units –including nurse stations, medication preparation rooms, and nurse rooms– were observed to be densely occupied by nurses. These areas also introduce a level of overcrowding in certain zones across the corridors within the two cases. Around the nurse stations, the staff were observed to interact with both families and patients seeking information about their conditions. At the nurse station in Case 2, trainee nurses were recorded attending the computer stations, which increased the occupant density around the area.

In each of the units, the medication preparation rooms and the nurse rooms were observed to be natural attractors for nurses who were assigned to patients located across the units. In Case 2, the LMO recordings suggest overcrowding in and around the medication room and nurse room, which were located apart from the nursing station, unlike the configuration in Case 1. Thus, the zones on corridors with excessive crowding are observed to be stretched for Case 2, where the nurse station, medication room, and the nurse room were not clustered around the center of the unit.

Nurse Activity Observation (NAO): The second type of observation concerning nurse activity indicated an intersection of a nurse's movement recordings using the shadowing method. In line with the location mappings, it was observed that the similar segments of the corridors at both units were predominantly occupied by nurses. The NAO findings for Case 1 (Figure 6) suggest that the nurse activity recordings mainly cluster around the medication preparation room (indicated by the green area), nurse



Figure 5. Comparison of staff traces of LMO in each unit.



Figure 6. NAO recordings overlapped in each unit.

station (indicated by the blue area), and the nurse room, which is parallel to the findings with occupancy recordings.

The graphic above shows that the auxiliary corridors on the edges in Cases 1 and 2 are less used by nurses for circulation due to availability of other opportunities of transition between the main corridors. In Case 2, it was observed that nurses' movement created excessive accumulation along the main corridor since the main corridor of this unit directly meets the entrance and is the main spine connecting the entire set of functional areas and the welcoming area. Moreover, the medication preparation room in Case 2 was observed to be included as part of the circulation route that links the northern corridor to the main corridor. The two doors for the medication room were predominantly open, and the nurses were observed to be passing through the area, which was used as a shortcut between the nurse station and the northern corridor. This observation also applies to the medication preparation room in Case 1 which also has access to both northern and southern corridors of the unit.

Space Syntax

Space syntax analysis focused on connectivity analysis via visual graph analysis (VGA) to understand 'the visual

accessibility of every location in the spatial system through the number of edges traversed to get from each to all others' (Varoudis & Psarra, 2014). Space connectivity analysis indicated that Case 1 has a visually well-connected spatial layout design, especially considering the corridor system. There are four intersection points on the main corridors that are considered the highest connectivity areas, like the crossroads of Case 1 (1 and 2 in Figure 7). The nurse station (3 in Figure 7), which is located at the intersection point, is the most connected area in the plan. In relation to the LMO and NAO recordings presented earlier, these connected areas also emerge as the most densely populated areas within the unit.

The connectivity analysis suggests that the northern corridor in Case 2 (Figure 8) has low connectivity levels compared to the main corridor in the unit, thus providing a level of isolation for the cluster of rooms facing north. The main corridor of the unit, on the other hand, seems to be creating a better-connected spine on which the nurse station, the medication room, and the nurse room are aligned. This segment of the corridor system in Case 2 has the potential to facilitate interactions between staff and patients, and also visitors.

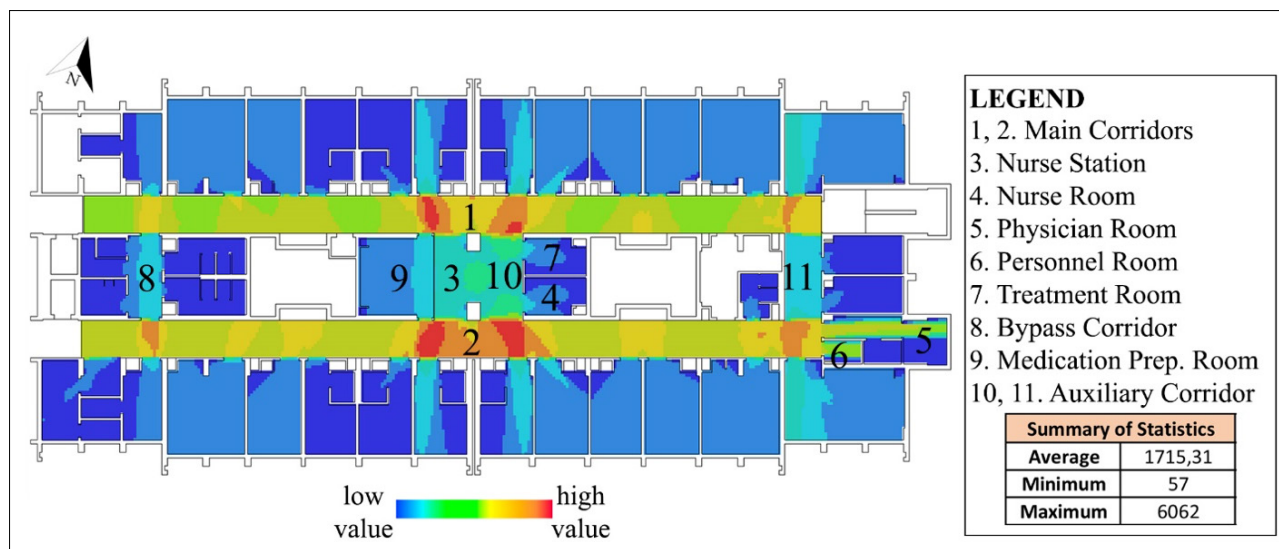


Figure 7. Connectivity analysis of case 1.

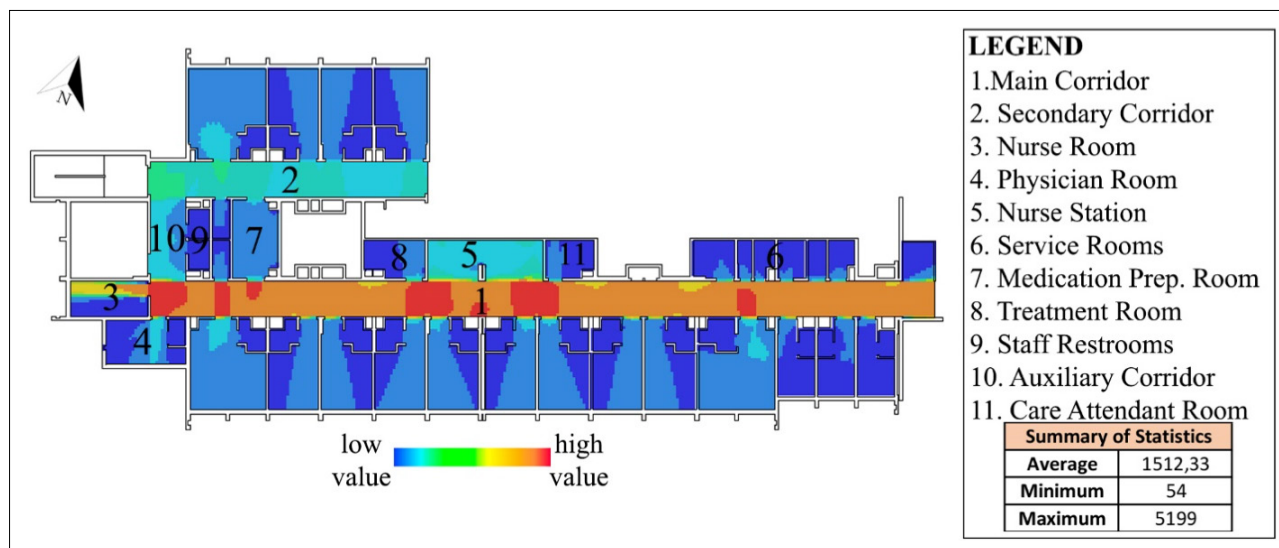


Figure 8. Connectivity analysis of Case 2.

Survey

The staff survey results suggest that the nurses regarded themselves as accessible to co-workers in terms of daily communication and work-related interactions. The nurses reported no significant barriers concerning visual and verbal communication which seemed to contribute to a level of situational awareness within the team. Most of the nurses stated that they were knowledgeable about the care processes of patients who were assigned to other nurses in the units.

According to the survey results obtained on the use of space, the most preferred areas for communicating with colleagues are nurse rooms, which are essential backstage areas for the mundane needs of staff (Figure 9). However, there is a slight difference between the two units that a small number

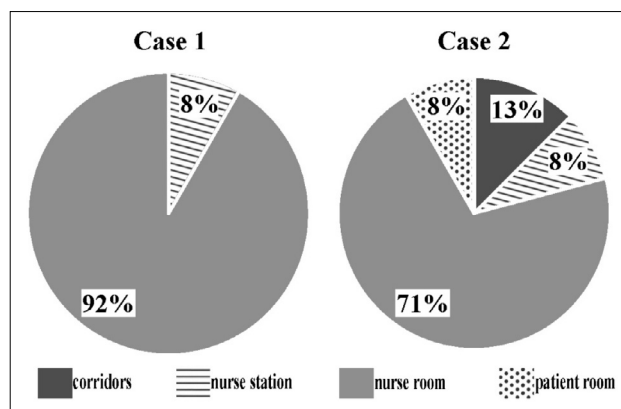


Figure 9. The most preferred place to communicate with colleagues.

of participants from Case 2 (13% of nurses) stated that they mostly preferred corridors to communicate with their colleagues, while other participants mentioned the nurse rooms and nurse stations. Contrary to the results obtained from observations, most of the nurses did not consider corridors as spaces for care-related communication.

The low number of participants made it difficult to conduct a deeper analysis beyond descriptive statistics. The drawing task within the survey, on the other hand, provided us with insights concerning occupants' perspective. The task requested nurses to mark their frequent routes during the shifts on a unit layout. The gathered data shows that

nurses preferred similar destination points and routes in each unit. The findings from the drawing task indicate that the medication preparation area, represented in green, is the primary destination for both units. As shown in Figure 10 which represents two sample drawings from two participants, the medication preparation room at both units were emphasized as both a destination and a transition area (a by-pass passage) between the corridors within the units.

Key Findings

1. The LMO and NAO recordings suggest that the allocation of the three key areas within the units,

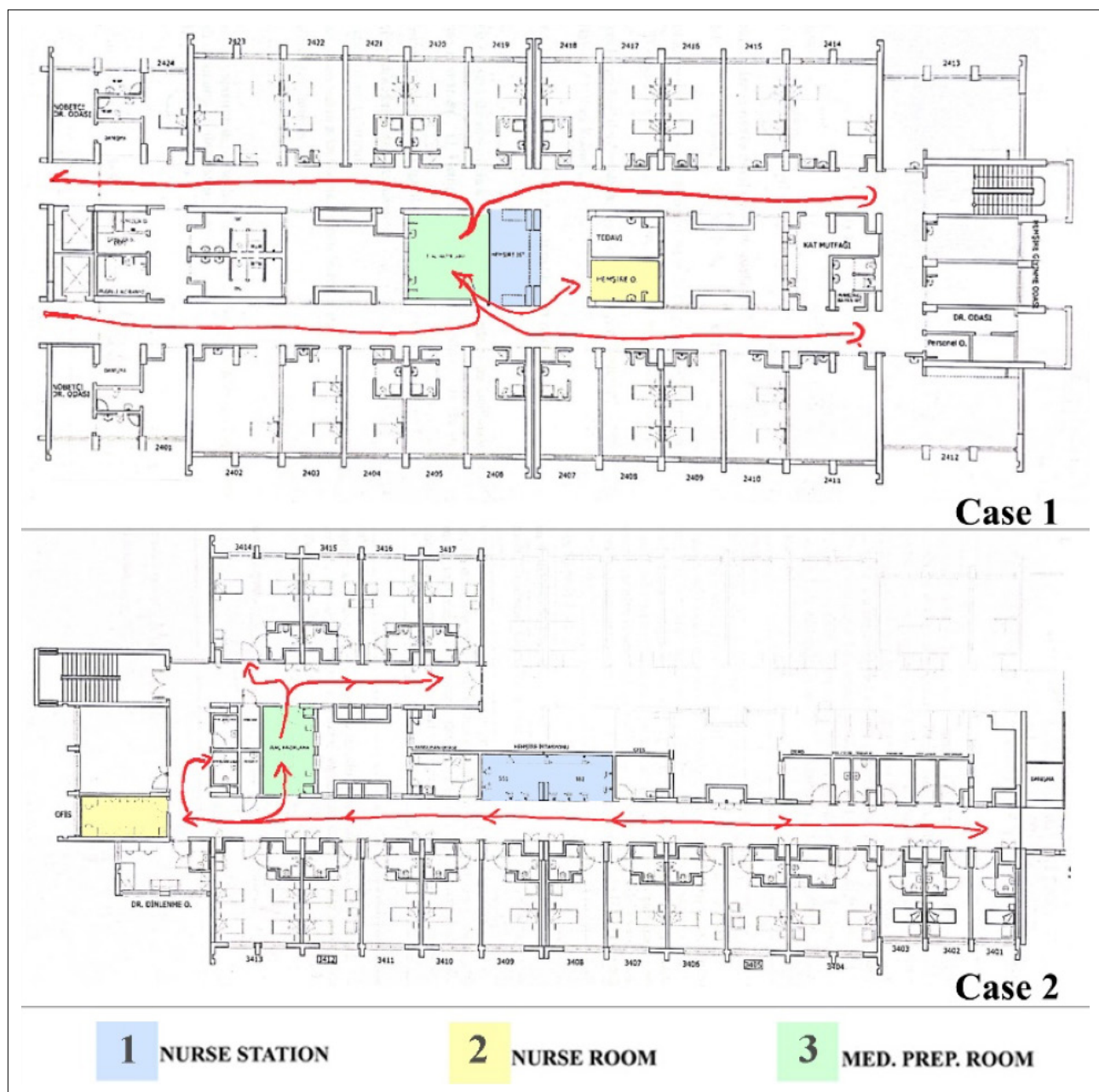


Figure 10. Drawings produced by two participants to show the most frequent routes within units.

namely the nurse station, the nurse room, and the medication preparation room, impacts the distribution of occupancy densities across the corridors. When these areas are located apart from each other, as in Case 2, the most densely occupied segment within the corridor spaces extends to include the route that links these three rooms. On the other hand, in Case 1, where the three rooms are clustered around the unit's center, the nurse activity traces were limited to the core area that included the nurse station, the nurse room, and the medication room.

2. The syntax analysis suggested that the nurse stations on both units were located on the most connected areas across the units. The most connected area in Case 1 also included the medication preparation room and the nurse room, thus making the key functional elements on the floor visually connected. In Case 2, the connectivity graph suggests a series of disconnected zones with high levels of connectivity distributed across the floor.
3. According to the observation results, corridors are the spaces where the nurses spend the majority of their time during shifts. However, the survey results suggest that the nurses mainly prefer nurse rooms for communication concerning care-related issues. In both units, the nurse rooms offer a level of isolation for nurses to maintain a level of privacy and confidentiality, which is considered as vital in a setting with no single-bed patient rooms.
4. The results of the drawing task within the nurse survey were in line with the NAO recordings. The nurses at the units are observed to be knowledgeable about the features of the units they work in, and were able to illustrate graphically the most frequent routes they follow on a daily basis.
5. The medication preparation rooms at both units emerges as one of the key attractors to generate high levels of occupancy. Both rooms have doors that connect the major circulation routes within units, thus creating by-pass passages to be employed by the nurses during their shifts. Both LMO and NAO observations and the drawing task provide data to confirm the situation with the medication preparation rooms.

DISCUSSION

The current section involves an interpretation of findings concerning the two cases studied. The discussion is presented through four key functional areas, namely corridors, nurse stations, nurse rooms and medication preparation rooms, which emerged as central to the analysis in relation to the research questions.

Corridors

The results show that the corridors were most frequently occupied areas by nurses in the two medical-surgical inpatient units. This may not seem like a novel finding because, typically, the corridors are acknowledged to be key areas to provide accessibility, control, and circulation in healthcare indoor environments (Carthey, 2008). There is research to suggest that corridors in healthcare settings are important as these spaces are key in coordination and communication (Carthey, 2008). The results indicate that there are specific zones that may contribute to even higher levels of circulation for certain segments across corridors, namely nurse room, nurse station, and medication preparation room. These staff-only areas are positioned as a cluster –in close proximity– in Case 1, while the mentioned areas are distributed across the corridor in Case 2. Accordingly, the observation recordings point out to the difference in circulation densities across corridors that link these key staff-related areas (Figure 11). Also, the dense areas within observation mappings seem to overlap with the zones with high levels of visual connectivity according to the space syntax analysis. This finding may suggest that the nurses tend to prefer locations or routes with high visibility.

As mostly emphasized in the literature, the corridors are favorable places where healthcare staff spend most of their shift time in a day, so these areas hold the potential to facilitate various forms of interactions between colleagues (Adams, 2008; Iedema et al., 2006; Pachilova et al., 2013; Setola et al., 2013). With particular focus on nurses' movement, a study by Hendrich et al. (2009) demonstrated that the patient assignments have a predictable impact on how nurses move through indoors. While the nurse assignment strategy is acknowledged to be a variable, the results of the current study suggest a reconsideration of the adjacencies of certain programmatic elements, other than patient rooms, which

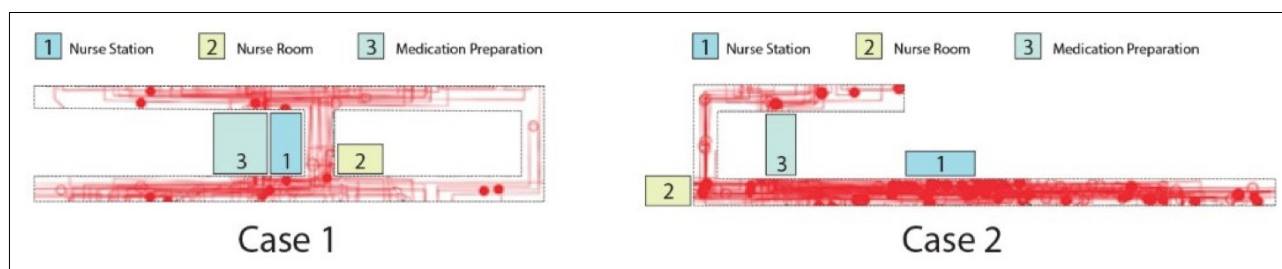


Figure 11. The densities of observation recordings at the unit corridors.

may have an impact on the frequently occupied locations and patterns of movement. The allocation of the three elements of the functional program, namely nurse stations, nurse rooms, and medication preparation rooms, and the proximities in-between raise further research questions concerning travel distances, planned and unplanned communication opportunities among colleagues and patient surveillance.

Yi & Seo (2012), to our knowledge, provide the only study to specifically focus on walking behavior and draw conclusions concerning the interrelation between paths that nurses follow and allocation and proximities for medication preparation room and nurse stations. They argue that “characteristics of the path that connects functional spaces such as patient room and medication area might better {Citation} nurses’ walking behavior” (Yi & Seo, 2012, p. 66) than the unit shape. In addition, the study suggests that the frequency of interruptions –for experienced nurses in particular– was influenced by the relationship between certain functional areas within units. While the current paper did not concern with the counts of unnecessary stops or unplanned interactions, our observations concur with Yi & Seo’s (2012) findings that micro-spatial organization of indoor environments and its influence on occupancy and movement patterns of nurses emerge as a critical factor to be further studied.

Nurse Stations

In the context of THS, centralized nurse stations are still predominantly used in inpatient units as opposed to emerging progressive models including distributed nurse station layouts. In Case 1 and 2, the nurse stations were located at the center of the units and were observed to be frequently occupied by staff members for a variety of purposes including coordination, face-to-face or phone-based communication, charting and related administrative duties. In both cases, nurse stations create a certain level of occupancy and circulation density around them which implies the potential for all forms of social interaction beyond care-related communication.

The literature suggests that centralized nurse stations positively contribute to nurse cooperation and communication (Zborowsky et al., 2010). Zborowsky et al. (2010) emphasize the importance of nurse stations as “the setting for frequent social interaction and formal and informal teaching and learning activities”. This situation is critical for the cases observed in this research in which the trainee nurses from the College of Nursing were always present to support care processes during shifts. The activities in and around the nursing stations within Case 1 and 2 certainly create an environment where less experienced members of the group learn by observing the behaviors, practices and decisions of seasoned nurses.

Other than the nurses of the units, the stations in both Case 1 and 2 were observed to be places inhabited temporarily by individuals from other departments. Zook et al. (2019) support the idea that during shifts the unit includes various temporary staff members, some of whom work in different parts of the hospital during the day. Integrated work areas within the unit, especially the stations, facilitate interaction among these groups, creating temporary communities of practice. Thus, understanding the patterns of activity for various participants in and around nursing stations and considering associated parameters, including proximities to other areas, levels of visual and acoustical privacy, and access, becomes critical in the centralized nurse station models.

Nurse Rooms

Considering the communication among colleagues, the nurse room is the most preferred space in both cases, according to the survey results (92% of the respondents in Case 1, 71% in Case 2). Moreover, it is noticeable in the drawing task that most of the respondents in both cases preponderantly marked the nurse room as part of their frequent routes during shifts. The observations also support the fact that nurse rooms were among the most frequently occupied areas within the two units (Figure 12).

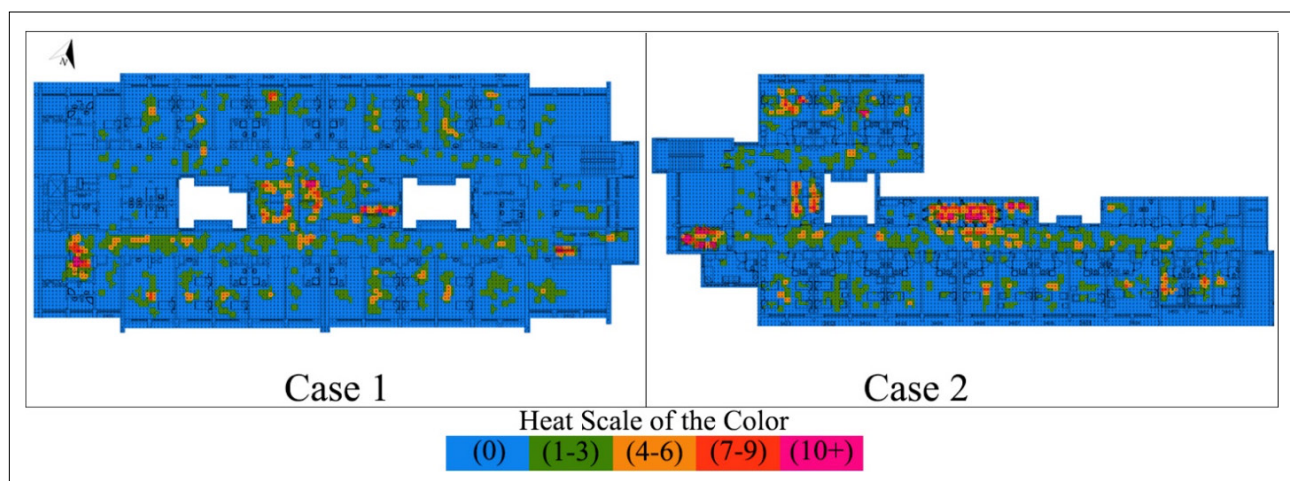


Figure 12. Heat maps from LMO Data to show densely occupied areas.

The literature proposes that nurse rooms should be positioned centrally within the unit and close to the nurse station (Adams, 2008; Nejati et al., 2016), and providing facilities for nurses to take respite, thereby potentially contributing to a positive impact on staff (Zhu & Shepley, 2022). The positioning of nurse rooms within units and how the nurses utilize these rooms are relatively different in both cases. The nurse room in Case 1 is used as a break room for the mundane activities of staff, and its door was observed to be closed all times during the shift in order to create a level of privacy. On the other hand, the nurse room in Case 2 –provided with a computer workstation– was being used as both a break room and an office. The healthcare facility regulations in Turkey do not provide specific guidance concerning the location and utilization of nurse rooms in inpatient units. Although the nurses did not express any complaints concerning the utilization of nurse rooms within the two units, it is important to clearly differentiate between whether the nurse room will serve as a nurse's office or a nurse's break room within the unit.

Medication Preparation Rooms

Keers et al. (2013)'s comprehensive review on medication administration errors reports eleven research studies that link occurrence of such adverse events to environmental features within healthcare facilities. Chaotic, distracting, and busy environments, for instance, were emphasized as conditions to cause medication errors. Existing research suggests that interruptions and distractions that medical staff experience are likely to increase the chances to result in errors (Duruk et al., 2016; Fore et al., 2013; Huckels-Baumgart et al., 2021)

The implementation of the “sterile cockpit” strategy in healthcare has been acknowledged to be an environment-related improvement to reduce medication administration errors (Fore et al., 2013). The model suggests that having a separate room for medication preparation (Huckels-Baumgart et al., 2021) and elimination of all forms of potential distractions and interruptions in inpatient units result in minimized occurrence of errors. For the cases observed in this research, the medication preparation rooms were not located as isolated and distant from the circulation areas while doors of both rooms in both units were always observed to be open during the fieldwork. Moreover, in

Cases 1 and 2, the medication preparation area was used as a transition area between the main corridors, according to the observational data and the results of the drawing task in nurse survey. In other words, the medication preparation rooms in Cases 1 and 2 were among the frequently occupied areas within the unit as the rooms are being utilized as a by-pass passage within nurses' circulation routes (Figure 13).

Huckels-Baumgart et al. (2021)'s observational study reports that having a separate medication preparation room, in order to limit frequent interruptions and distractions, mostly initiated by colleagues, has a positive effect to decrease medication errors. The suggestion to implement a separate area reserved for medication preparation is already implemented in the units studied in this research. The location and configuration of these areas, and daily work practices of nursing staff in the unit seem to contribute to the heavy traffic within and around the medication preparation rooms. The current research did not seek any correlation between the number of medication errors and the features of indoors for the cases. However, the issue is acute in the context of THS, and further research is needed to better understand the role of environments within causal links that result in medication errors and to guide and influence regulatory documents in healthcare construction.

This section discusses that the findings of this study regarding the spatial occupancy practices of nurses indicate a remarkable situation when evaluated in the context of national spatial standards for healthcare facilities in Turkey. The Ministry of Health of Turkey's guidelines (such as Ministry of Health of Turkey Inpatient Health Facilities Planning Guide (2011)) focus on technical aspects like facility functionality, hygiene, accessibility, and security. However, they only briefly address how healthcare staff, especially nurses, interact with the space, which requires more qualitative consideration. Moreover, the circulation, communication and care activities that nurses carry out between different spaces in their daily workflow are a direct output of spatial organization. This situation demonstrates a gap between current standards and user experiences, highlighting the need for new initiatives aligned with user-centered and evidence-based design principles. Although it can be argued that the knowledge concerning the user experience is already known implicitly by healthcare designers in the context of Turkey, it is still important to

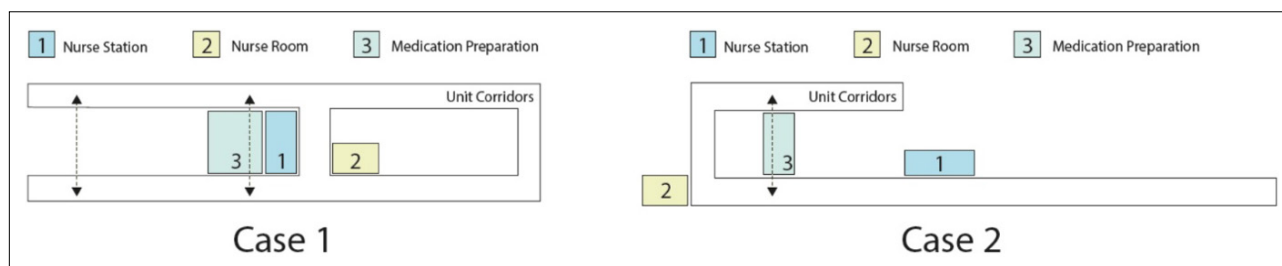


Figure 13. Unit corridors and by-pass passages.

express abovementioned design concerns explicitly in the next editions of healthcare design guidelines.

CONCLUSION

A growing body of research suggests a strong link between the layout of spaces and communication within healthcare settings, especially among staff, as it has a consequential effect on the quality of care and patient outcomes. (Cai & Zimring, 2012; Haron et al., 2012; Pachilova et al., 2013). Spatial measurements correlate robustly with nurses' distribution, interaction, and mutual awareness (Cai & Zimring, 2012) since the spatial arrangement within healthcare facilities can bring together healthcare staff during their shifts, influencing their experiences, communication, and behavior. Continuing the discussion on communication and interaction in healthcare environments, this study aimed to investigate key factors –occupancy and movement– which are recognized as primary variables affecting the levels and frequency of communication among nurses within inpatient units.

The study's findings revealed that the different spatial layouts and the allocation of programmatic elements within created different patterns of occupancy and movement. While there are morphological distinctions among the units, the results indicate that specific functions arise to influence occupancy and movement. Particular segments within corridors emerge as crucial areas where nurses predominantly spend their time, having potential to facilitate a level of awareness among colleagues. The study has highlighted various key elements within corridors that encourage increased movement, including nurse stations, nurse rooms, and medication preparation areas in the examined units.

According to current research, the medication preparation room, a key area for care procedures within units, should be strategically designed on the floor plan to minimize unnecessary traffic flow. Furthermore, the room should adhere to design principles to reduce distractions, as the literature indicates that communication and interruptions in medication preparation areas can contribute to medical errors. However, the results of this research show that the medication preparation room is utilized for interaction, communication, and information exchange, as well as for preparing drugs. The room for preparing medications serves as a connecting corridor between the main hallways during specific cases. Consequently, the presence of these two medication preparation rooms in cases 1 and 2 has influenced both the intensity and the trajectory of nurse circulation on the corridors, as they have become the most frequent destination for nurses. Hence, when planning the design of medication preparation rooms, designers must take into account various factors, including selecting appropriate locations and sizes within the unit, and their integration with circulation pathways and other high-traffic areas.

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REFERENCES

- Adams, R. (2008). *The role of physical design and informal communication and learning in gaining competency and reducing stress among graduate nurses* [Master Thesis]. Cornell University.
- Aksoy, E., Aydın, D., & İskifoğlu, G. (2020). Analysis of the correlation between layout and wayfinding decisions in hospitals. *Megaron*, 15(4), 509–520. <https://jag.journalagent.com/megaron/pdfs/MEGARON-21797-ARTICLE-AKSOY.pdf>
- Allison, D. (2007). Hospital as city: Employing urban design strategies for effective wayfinding. *Health Facilities Management*, 20(6), 61–65.
- Ampt, A., Harris, P., & Maxwell, M. (2008). *The health impacts of the design of hospital facilities on patient recovery and wellbeing, and staff wellbeing: A review of the literature*. Centre for Primary Health Care and Equity.
- Cai, H. (2012). *Making “invisible architecture” visible: A comparative study of nursing unit typologies in the United States and China* [PhD Dissertation]. Georgia Institute of Technology.
- Cai, H., & Zimring, C. (2012). Out of sight, out of reach: Correlating spatial metrics of nurse station typology with nurses' communication and co-awareness in an intensive care unit. *Proceedings: Eighth International Space Syntax Symposium*, 36, 381–391.

- Cansever, İ. H., & Gökkaya, D. (2022). From Numune Hospitals to city hospitals: Past, present and future of hospitals in Turkey [Numune hastanelerinden şehir hastanelerine: Türkiye’de hastanelerin dünü, bugünü ve yarını]. *Balıkesir Sağlık Bilimleri Dergisi*, 12(2), 425–436. <https://dergipark.org.tr/en/pub/balikesirsbd/article/1070010>
- Carthey, J. (2008). Reinterpreting the hospital corridor: “Wasted space” or essential for quality multidisciplinary clinical care? *HERD: Health Environments Research & Design Journal*, 2(1), 17–29. <https://doi.org/10.1177/193758670800200103>
- Codinhoto, R., Tzortzopoulos, P., Kagioglou, M., Aouad, G., & Cooper, R. (2009). The impacts of the built environment on health outcomes. *Facilities*, 27(3–4), 138–151. <https://www.emerald.com/insight/content/doi/10.1108/02632770910933152/full/html>
- Coiera, E., Jayasuriya, R. A., Hardy, J., Bannan, A., & Thorpe, M. E. (2002). Communication loads on clinical staff in the emergency department. *Medical Journal of Australia*, 176(9), 415–418.
- Devlin, A. S., & Arneill, A. B. (2003). Health care environments and patient outcomes: A review of the literature. *Environment and Behavior*, 35(5), 665–694. <https://doi.org/10.1177/0013916503255102>
- Donchin, Y., Gopher, D., Olin, M., Badihi, Y., Biesky, M., Sprung, C. L., Pizov, R., & Cotev, S. (2003). A look into the nature and causes of human errors in the intensive care unit. *BMJ Quality & Safety*, 12(2), 143–147. <https://doi.org/10.1136/qhc.12.2.143>
- Duruk, N., Zencir, G., & Eser, I. (2016). Interruption of the medication preparation process and an examination of factors causing interruptions. *Journal of Nursing Management*, 24(3), 376–383. <https://doi.org/10.1111/jonm.12331>
- Edgerton, E., Ritchie, L., & McKechnie, J. (2010). Objective and subjective evaluation of a redesigned corridor environment in a psychiatric hospital. *Issues in Mental Health Nursing*, 31(5), 306–314. <https://doi.org/10.3109/01612840903383976>
- Ergenoğlu, A., & Tanrıtanır, A. (2013). Evaluation of architectural spatial quality in patients’ rooms in the context of user satisfaction in general hospitals: A case study in Gaziantep [Genel hastanelerde kullanıcı memnuniyeti açısından hasta odalarında mimari mekân kalitesinin irdelenmesi: Gaziantep ilinde bir alan çalışması]. *Megaron*, 8(2), 61–75.
- Fore, A. M., Sculli, G. L., Albee, D., & Neily, J. (2013). Improving patient safety using the sterile cockpit principle during medication administration: A collaborative, unit-based project. *Journal of Nursing Management*, 21(1), 106–111. <https://doi.org/10.1111/j.1365-2834.2012.01410.x>
- Gharaveis, A., Hamilton, D. K., & Pati, D. (2018). The impact of environmental design on teamwork and communication in healthcare facilities: A systematic literature review. *HERD: Health Environments Research & Design Journal*, 11(1), 119–137. <https://doi.org/10.1177/1937586717730333>
- Gomez-Zamora, P., Bafna, S., Zimring, C., Do, E., & Romero V., M. (2019). In Sousa, J. P., Henriques, G. C. & Xavier, J. P., eds. *Spatiotemporal occupancy for building analytics. Architecture in the Age of the 4th Industrial Revolution: Proceedings of the 37th eCAADe and 23rd SIGraDi Conference*, pp. 111–120. https://doi.org/10.5151/proceedings-ecaadesigradi2019_153
- Haron, S. N., Hamida, M. Y., & Talib, A. (2012). Towards healthcare service quality: An understanding of the usability concept in healthcare design. *Procedia – Social and Behavioral Sciences*, 42, 63–73. <https://doi.org/10.1016/j.sbspro.2012.04.167>
- Hendrich, A. (2003). *Optimizing physical space for improved outcomes: Satisfaction and the bottom line*. Institute for Healthcare Improvement and the Center for Health Design.
- Hendrich, A., Chow, M. P., Bafna, S., Choudhary, R., Heo, Y., & Skierczynski, B. A. (2009). Unit-related factors that affect nursing time with patients: Spatial analysis of the time and motion study. *HERD: Health Environments Research & Design Journal*, 2(2), 5–20. <https://doi.org/10.1177/193758670900200202>
- Huckels-Baumgart, S., Baumgart, A., Buschmann, U., Schüpfer, G., & Manser, T. (2021). Separate medication preparation rooms reduce interruptions and medication errors in the hospital setting: A prospective observational study. *Journal of Patient Safety*, 17(3), e161–e168. https://journals.lww.com/journalpatientsafety/fulltext/2021/04000/separate_medication_preparation_rooms_reduce.21.aspx
- Iedema, R., Long, D., Carroll, K., Stenglin, M., & Braithwaite, J. (2006). *Corridor work: How liminal space becomes a resource for handling complexities of multi-disciplinary health care*. APROS, 238.
- Iyendo, T. O., Uwajeh, P. C., & Ikenna, E. S. (2016). The therapeutic impacts of environmental design interventions on wellness in clinical settings: A narrative review. *Complementary Therapies in Clinical Practice*, 24, 174–188. <https://doi.org/10.1016/j.ctcp.2016.06.008>
- Jiang, S., & Verderber, S. (2017). On the planning and design of hospital circulation zones: A review of the evidence-based literature. *HERD: Health Environments Research & Design Journal*, 10(2), 124–146. <https://doi.org/10.1177/1937586716672041>
- Joseph, A. (2006). *The role of the physical and social environment in promoting health, safety, and effectiveness in the healthcare workplace*. Center for Health Design.
- Keers, R. N., Williams, S. D., Cooke, J., & Ashcroft, D. M.

- (2013). Causes of medication administration errors in hospitals: A systematic review of quantitative and qualitative evidence. *Drug Safety*, 36(11), 1045–1067. <https://doi.org/10.1007/s40264-013-0090-2>
- Lim, L., Kanfer, R., Stroebel, R. J., & Zimring, C. M. (2020). Backstage staff communication: The effects of different levels of visual exposure to patients. *HERD*, 13(3), 54–69. <https://doi.org/10.1177/1937586719888903>
- Lu, Y., Peponis, J., & Zimring, C. (2009). *Targeted visibility analysis in buildings: Correlating targeted visibility analysis with distribution of people and their interactions within an intensive care unit*. Proceedings of the 7th International Space Syntax Symposium.
- Nejati, A., Shepley, M., Rodiek, S., Lee, C., & Varni, J. (2016). Restorative design features for hospital staff break areas: A multi-method study. *HERD: Health Environments Research & Design Journal*, 9(2), 16–35. <https://doi.org/10.1177/1937586715592632>
- Pachilova, R., & Sailer, K. (2015). *Size and complexity of hospitals matter for quality of care: A spatial classification of NHS buildings*. SSS 2015 – 10th International Space Syntax Symposium.
- Pachilova, R., & Sailer, K. (2020). Providing care quality by design: A new measure to assess hospital ward layouts. *The Journal of Architecture*, 25(2), 186–202. <https://doi.org/10.1080/13602365.2020.1733802>
- Pachilova, R., Sailer, K., & King, M. (2013). *Evidence-based design: The effect of hospital layouts on the caregiver-patient interfaces*. Proceedings of the Second European Conference on Design 4 Health.
- Rashid, M. (2009). Hospital design and face to face interaction among clinicians: A theoretical model. *HERD: Health Environments Research & Design Journal*, 2(4), 62–84. <https://doi.org/10.1177/193758670900200404>
- Sailer, K., Pachilova, R., Kostopoulou, E., Pradinuk, R., MacKinnon, D., & Hoofwijk, T. (2013). *How strongly programmed is a strong programme building? A comparative analysis of outpatient clinics in two hospitals*. 2013 International Space Syntax Symposium
- Setola, N., Borgianni, S., Martinez, M., & Tobari, E. (2013). *The role of spatial layout of hospital public spaces in informal patient-medical staff interface*. Proceedings of the Ninth International Space Syntax Symposium, 1–11. <https://flore.unifi.it/handle/2158/1011655>
- Shepley, M. M. (2002). Predesign and postoccupancy analysis of staff behavior in a neonatal intensive care unit. *Children's Health Care*, 31(3), 237–253. https://doi.org/10.1207/S15326888CHC3103_5
- Shepley, M. M., Peditto, K., Sachs, N. A., Pham, Y., Barankevich, R., Crouppen, G., & Dresser, K. (2022). Staff and resident perceptions of mental and behavioural health environments. *Building Research & Information*, 50(1–2), 89–104. <https://doi.org/10.1080/09613218.2021.1963653>
- T.C. Sağlık Bakanlığı. (2011). *Ministry of Health Inpatient Health Facilities Planning Guide: Summary Book [Sağlık Bakanlığı Yataklı Sağlık Tesisleri Planlama Rehberi: Özet Kitap]*. Tedavi Hizmetleri Genel Müdürlüğü.
- Tomé, A., Kuipers, M., Pinheiro, T., Nunes, M., & Heitor, T. (2015). Space-use analysis through computer vision. *Automation in Construction*, 57, 80–97. <https://doi.org/10.1016/j.autcon.2015.04.013>
- Trinkoff, A. M., Johantgen, M., Muntaner, C., & Le, R. (2005). Staffing and worker injury in nursing homes. *American Journal of Public Health*, 95(7), 1220–1225. <https://doi.org/10.2105/AJPH.2004.045070>
- Tyson, G. A., Lambert, G., & Beattie, L. (2002). The impact of ward design on the behaviour, occupational satisfaction and well-being of psychiatric nurses. *International Journal of Mental Health Nursing*, 11(2), 94–102. <https://doi.org/10.1046/j.1440-0979.2002.00232.x>
- Ulrich, R., Zimring, C., Zhu, X., DuBose, J., Seo, H. B., Choi, Y. S., Quan, X., & Joseph, A. (2008). A review of the research literature on evidence-based healthcare design. *HERD: Health Environments Research & Design Journal*, 1(3), 61–125. <https://doi.org/10.1177/193758670800100306>
- Varoudis, T., & Psarra, S. (2014). Beyond two dimensions: Architecture through three-dimensional visibility graph analysis. *The Journal of Space Syntax*, 5(1), 91–108. <https://discovery.ucl.ac.uk/id/eprint/1477266/>
- Weick, K. E., & Sutcliffe, K. M. (2003). Hospitals as cultures of entrapment: A re-analysis of the Bristol Royal Infirmary. *California Management Review*, 45(2), 73–84. <https://doi.org/10.2307/41166166>
- Yi, L., & Seo, H. B. (2012). The effect of hospital unit layout on nurse walking behavior. *HERD: Health Environments Research & Design Journal*, 6(1), 66–82. <https://doi.org/10.1177/193758671200600104>
- Zborowsky, T., Bunker-Hellmich, L., Morelli, A., & O'Neill, M. (2010). Centralized vs decentralized nursing stations: Effects on nurses' functional use of space and work environment. *HERD: Health Environments Research & Design Journal*, 3(4), 19–42. <https://doi.org/10.1177/193758671000300404>
- Zhang, Y., Tzortzopoulos, P., & Kagioglou, M. (2019). Healing built-environment effects on health outcomes: Environment-occupant-health framework. *Building Research & Information*, 47(6), 747–766. <https://doi.org/10.1080/09613218.2017.1411130>
- Zhu, X., & Shepley, M. M. (2022a). Assessing preferences and perceived restorative qualities of break spaces for nurses in China. *HERD: Health Environments Research & Design Journal*, 15(3), 126–142. <https://doi.org/10.1177/19375867221075837>
- Zook, J., Nanda, U., & Renner, K. (2019). *ICU as informational interface: A model for data-driven ICU design*. 12th International Space Syntax Symposium (SSS 2019).



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Article

Spatial readings in new generation learning environments: The case of Gökçeada High School Campus

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ABSTRACT

In the 20th century, learning spaces began to change in parallel with the transition from traditional pedagogies to student-centered learning. In the 21st-century, the transformation of space continues in the context of contemporary skills and new generation learning. This article aims to evaluate the relationship between learning and space in new-generation learning environments by examining the potential for spatial usage in educational buildings. The study will consider the Gökçeada High School Campus as a case study, as it was implemented as an innovative and exemplary model. Analyses were carried out on the educational building on the campus and the learning spaces associated with it. The learning approaches supported by the spaces were determined using a plan reading method developed by Dovey & Fisher based on Assemblage theory. The spatial usage potential of the school in the context of new-generation learning is evaluated based on the findings and learning modes obtained. According to the findings, while the school primarily offers traditional learning spaces, it also provides innovative ones. It has been determined that new-generation learning applications are possible in the educational building that accommodates innovative spaces, such as flexible classrooms, street-spaces and special open commons. The study's original contribution is its analysis of an implemented national innovative educational building, revealing formal, informal or integrated (formal & informal) learning modes through spatial typologies. In this context, suggestions are presented on how the current design of Gökçeada High School can be adapted to accommodate new generation learning and contemporary needs, and strategies are proposed for redesigning traditional learning spaces.

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INTRODUCTION

The 20th century was a period of transformation in educational buildings under the influence of constructivist pedagogy. Pedagogical approaches that evolved in line with psychology-based learning theories also impacted the

learning space in parallel with the change processes. In this process of change, there was a transition from traditional pedagogies to student-centered, new generation pedagogies at all levels of education from pre-school to higher education (Tusting & Barton, 2013; Olugbenga, 2021; Shah, 2021). As the learning space was reshaped by these new generation

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pedagogies, the act of learning moved beyond traditional classrooms behind closed doors accessed through closed corridors, and informal learning spaces, where a variety of experiences could be gained, have become as important as formal learning spaces. In this context, student-centered educational buildings have gained importance in order to achieve effective and successful learning (Oblinger, 2006; Nair et al., 2009; OECD, 2013). Learning spaces, redesigned according to changing pedagogy and needs, continue their transformation as a support system in the education of individuals according to 21st-century skills and learning frameworks (Çiftçi, 2021; Tang, 2020).

Today, student-centred and technologically advanced learning spaces are required to cater for the learning styles, interests and needs of the new generation of students. These innovative learning spaces are also required by the frameworks of 21st-century skills that aim to develop competent individuals in every field (Brown & Long, 2006; Nair et al., 2009; OECD, 2013; Tang, 2020; Çiftçi et al., 2021). However, while very few educational institutions can offer their students learning environments that meet contemporary needs, the majority are still limited to traditional classrooms, teacher-centred pedagogies that insist on uniformity and outdated standards. Since current educational buildings are shaped under the influence of traditional pedagogies, they cannot allow the implementation of new generation pedagogies and cannot meet the requirements of 21st-century education. The widening gap between the educational environments offered to students affects not only the education system, but also the personal development of individuals and therefore societal development. For this reason, spaces must be designed where new-generation learning can be implemented. These spaces must be adaptable to all segments and levels of educational buildings and take into account contemporary needs and current learning approaches (Atabay, 2014; Güzer, 2014; Tang, 2020; Petrova et al., 2022).

New generation learning spaces encourage educators to implement innovative pedagogies that were previously limited in traditional classrooms and allow students to participate in a variety of learning experiences that are common in many schools. These spaces make interdisciplinary education, collaborative learning and personalised curricula more accessible (Atabay, 2014; Dovey & Fisher, 2014; Imms et al., 2017). Against the backdrop of the importance of space in the learning process, this article aims to evaluate the relationship between learning and space in new-generation learning environments by interpreting the spatial usage possibilities in educational buildings. The Gökçeada High School Campus, implemented as an innovative national

exemplary model, is examined as a case study and its usage possibilities in the context of new-generation learning are analysed. To conduct this analysis, the method proposed by Dovey & Fisher (2014) to understand the connections between space and pedagogy is employed and evaluations made in line with data obtained through a literature review. Although this analysis method has been used in many foreign studies (e.g. Soccio & Cleveland, 2015; Imms et al., 2016; Imms et al., 2017), only Göksoy (2021) has included the method in a national study as a component of a model that she designed to understand the spatial approach of educational buildings. She examined projects that awarded in a competition but were not implemented, to analyse traditional and new-generation spaces. In this study, an implemented and national educational building example was taken into account. The findings were evaluated along with the learning modes included in the learning spaces and, how and to what extent new generation learning was provided was investigated. The results of the study will provide a valuable framework for identifying the critical factors that should be considered in the design and management process of new generation learning spaces.

As seen in Figure 1, a comprehensive literature review was conducted in the first stage of the study. As a result of the research conducted in this stage, learning modes, learning space shaped by the influence of pedagogies and new generation learning spaces are defined under the title 'The Relationship Between Learning and Space'. In the second stage, the methodology of the study using case analysis is mentioned. After defining the study area, the analysis process is explained. The third stage involves analysing the Gökçeada High School Campus and related learning spaces. In the fourth stage, all the findings obtained in the study are evaluated and in the conclusion section, the general purpose and importance of the study, rapid developments in the field of education, pedagogical and spatial dynamics are interpreted together.

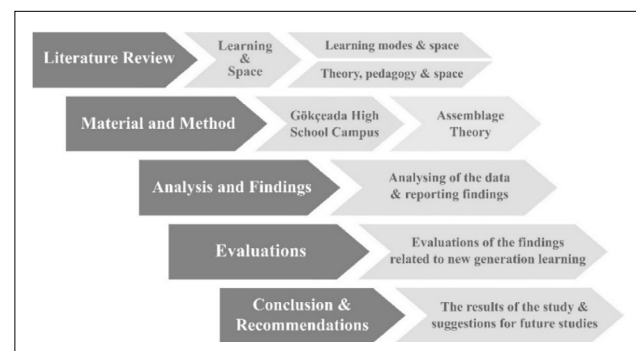


Figure 1. Flow chart of the study (Created by the Author).

The Relationship Between Learning and Space

Learning modes and space

While there are many definitions of the concept of learning, Taylor (2009) defines the realisation of learning as a system in which three components work together: The information learned, the learning model and the learning space. In summary, learning, defined as a permanent change in behaviour and meanings in the minds of individuals as a result of their observations and experiences, is a process that cannot be limited to formal education and training and continues throughout life, anytime and anywhere. Learning environments in school and out of school, in all natural and artificial environments include places where different modes of learning take place, which can be treated as formal, non-formal and informal (Eshach, 2007; Erman & Gümüşburun Ayalp, 2022). Learning is expressed in different modes depending on the place where it is planned and is evaluated in different categories. These learning modes are compared in detail in Table 1.

Formal learning, which consists of structured content organised for a purpose, takes place under the leadership of a teacher according to a pre-planned curriculum in formal places, such as schools, where there are rules and regulations. Non-formal learning, which, like formal learning, is organised for a purpose and occurs in the presence of a leader, is usually structured in non-school places. Informal learning, on the other hand, is a type of learning that, unlike formal learning, is not organised, structured in terms of time and place, whether it is purposeful or not, and anywhere from the schoolyard to the street can be a place for informal learning (Aydın, 2011; Danielle Colardyn, 2004; Dib, 1988; Eshach, 2007). Formal and informal learning modes, which are evaluated in separate categories and require different environments, constitute integrated learning environments when they are intertwined and designed together, as shown in Figure 2.

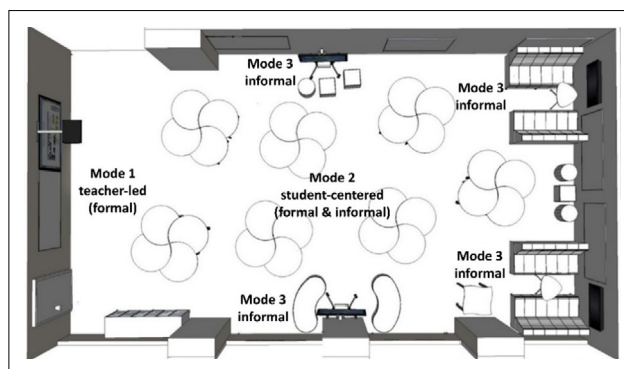


Figure 2. New generation learning space that accommodates formal and informal learning modes (Adapted from Byers, Imms & Hartnell-Young, 2014).

While non-formal learning cannot take place in educational buildings due to its content, learning spaces that integrate informal and formal learning modes, as shown in Figure 2, are replacing traditional classrooms where only formal learning takes place. Especially with the influence of new generation learning approaches, there has been a trend towards integrated learning spaces where different learning modes are intertwined. These approaches continue to shape learning spaces and are updated in line with the needs of the 21st-century learner (Oblinger, 2006; Nair et al., 2009; Dovey & Fisher, 2014).

Learning theory, pedagogy and space

Questioning the relationship between learning and space is a deep issue that also requires questioning the relationship between theory and pedagogy. Learning theories are sets of principles that explain how learners acquire, store and remember information (Ormrod, 2011). Pedagogies are educational models that aim to use appropriate materials, methods and environments that will support student learning by benefiting from these theories (Olugbenga, 2021; Shah, 2021). Throughout history, pedagogical approaches have naturally changed and diversified in the processes of questioning learning and changing

Table 1. Comparison of learning modes (Eshach, 2007)

Formal Learning	Non-formal learning	Informal learning
Usually at school	At institution out of school	Everywhere
May be oppressive	Usually supportive	Supportive
Structured	Structured	Unstructured
Usually prearranged	Usually prearranged	Spontaneous
Motivation is typically more extrinsic	Motivation may be extrinsic but it is typically more intrinsic	Motivation is mainly intrinsic
Compulsory	Usually voluntary	Voluntary
Teacher-led	May be guide or teacher-led	Usually learner-led
Learning is evaluated	Learning is usually not evaluated	Learning is not evaluated
Sequential	Typically non-sequential	Non-sequential

perspectives on learning. The spaces in which learning takes place have also been reshaped during these changes. Many pedagogies, from traditional to new generations, that have been influenced by learning theories have directly affected and shaped formal learning space in particular (Dovey & Fisher, 2014; Erman & Gümüşburun Ayalp, 2022).

In early educational buildings, learning spaces were shaped by traditional pedagogies under the influence of behaviorist theory. The traditional classroom layout is an example of the spatial equivalent of traditional pedagogy. In this layout, students sit at regularly arranged desks facing the teacher and the board. This minimises their interactions with each other and allows them to focus only on the teacher. This makes it easier for the teacher to discipline the class and observe and control all students (Erman & Gümüşburun Ayalp, 2022). As seen in the example in Figure 3, the Lancastrian or Monitorial education system, which emerged in England and is presented as an example of a classroom layout shaped by traditional educational pedagogy. In this education system, there are long desks lined up for students in a rectangular classroom and an area raised from the ground for the teacher's authority and dominance over the class. The classroom floor rising forward from the teacher's desk and the sloping seating arrangement further emphasise the teacher's authoritarian role. Thus, even students sitting at the back can be observed and supervised by the teacher (Figure 3).

On the other hand, cognitive theory has fed into traditional pedagogies such as behaviourist theory, by limiting learning to mental processes and failing to take social and cultural factors sufficiently into account. According to cognitive theory, the way in which information is processed, stored and restructured in the mind is important. Individuals must actively attribute meaning to information (Piaget, 1950; Bruner, 1966; Tusting & Barton, 2013). Consequently, learning spaces are designed to enhance learner attention and facilitate information organisation. Quiet, orderly, individual study areas, such as laboratories and libraries, are examples of spaces that support traditional pedagogies influenced by cognitive theory, as they provide suitable environments for individual thought and information organisation (Brooks, 2012). For traditional pedagogies

based on behaviorist and cognitive theories, an educational building model emerged in which classes of the same size were lined up in two directions along a corridor, and this educational building model was called the factory type. This factory typology was typified as a plan in which classroom series were connected by corridors and became traditional, shaping school buildings throughout the 20th century (Erman & Gümüşburun Ayalp, 2022).

From the 20th century onwards, theories that centred on the student as an active participant in the learning process began to emerge. The most prominent of these are constructivist theory, social constructivism, social learning and experiential learning theories. As these theories emerged, traditional educational approaches became less effective, prompting a transition to new generation pedagogies. The progressive education model, the Montessori model, the Reggio Emilia model, social constructivist pedagogies and collaborative pedagogies are among these new generation pedagogies, which are still influential today and directly shape learning spaces (Driscoll, 2005; Woolner, 2010; Schunk, 2020; Olugbenga, 2021; Erman & Gümüşburun Ayalp, 2022).

Unlike previous theories, these new-generation pedagogies, which emphasise the importance of social interaction, collaboration and individual experiences for learning to take place, have transformed learning spaces in line with this perspective. As illustrated in Figure 4, there has been a shift towards spaces offering students greater autonomy and choice. These spaces include social areas for various purposes and encourage exploration and problem-solving. They are also flexible and modular, collaborating with students throughout the process (Erman & Gümüşburun Ayalp, 2022; Chand, 2024). Figure 5 shows examples of learning spaces that facilitate the implementation of these pedagogies.

In the 21st-century, technological advances have enriched and made learning more accessible. Current educational models, such as digital pedagogy, Education 4.0 and hybrid learning, have emerged under the influence of new theories, such as connectivism and technology-supported learning, which have been created by technological advances. These approaches emphasise the importance of digital literacy, access to information, and knowledge sharing (Siemens, 2005; Laurillard, 2012). This necessitates the digitisation of educational processes and learning spaces, as well as their integration with innovative approaches. Although these technological innovations do not directly transform the form of the space, they require the integration of digital tools in flexible spaces needed in the context of new generation learning and the creation of mobile learning areas. Smart classrooms, online learning platforms, VR/AR equipped learning environments, multi-purpose rooms supported by the internet and technological infrastructure are shown as examples of today's innovative understanding where flexible

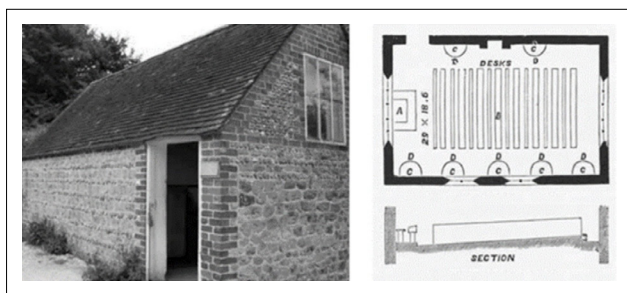


Figure 3. An example for Lancaster type school (Burke & Grosvenor, 2008).

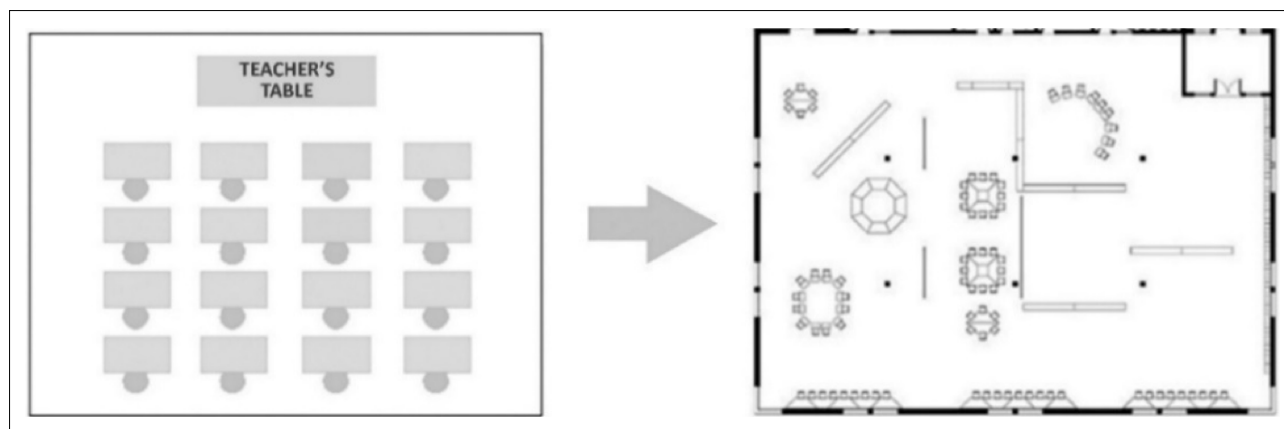


Figure 4. From a traditional classroom schema (Taylor, 2009) to an open-plan school schema (Lippman, 2010).



Figure 5. Learning spaces for new generation (Imms et al., 2017).

spaces are at the forefront and suitable for hybrid learning models (Brown & Long, 2006; Laurillard, 2012).

As shown in Table 2, effective learning models in the 21st-century are much more different and diverse than traditional learning models of earlier periods. Since the effective implementation of these new generation pedagogies requires appropriate physical environments designed to adapt to diversified needs, the functioning and appearance of learning spaces have also changed (Fisher, 2005; Oblinger, 2006; Tang, 2020). In this context, new-generation learning spaces allow educators to implement new generation pedagogies effectively and efficiently, becoming involved in the learning process as a third teacher (Edwards, 2011; Mahat et al., 2018).

MATERIAL AND METHOD

The study was carried out within the scope of the educational building of Gökçeada High School Campus. The selection of Gökçeada High School Campus as the study area was influenced by the fact that it is a campus

that aims to implement an alternative, innovative, student-centred, participatory and transparent educational model (TRT 2, 2023); that it is a qualified building that is claimed by its architects to be an innovative and exemplary model by emphasising the relationship between the educational model and the space; and that it was obtained through a competition and received many awards after its construction was completed (Arkitera, 2019; PAB Architecture, n.d.).

The aim of the research is to analyse how all spaces, from classrooms to open spaces, and the relationship between these spaces respond to new generation pedagogies. The analysis is limited to the ground and first floors of the building, with permission to share. The method used is the plan reading method developed by Dovey & Fisher (2014), using the infrastructure of Assemblage theory.

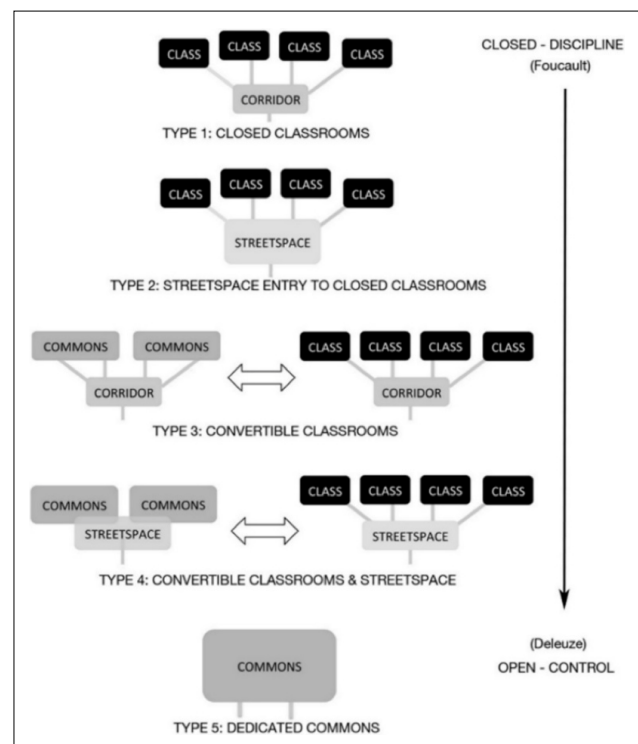
Assemblage theory, a concept developed by Deleuze & Guattari (1987), analyses how spatial processes and arrangements interact with not only physical but also social and cultural factors. The theory emphasises not only the physical characteristics of spaces, but also their interaction with the elements within them and how they carry meaning

Table 2. Featured theories and pedagogies that have a significant impact on the learning spaces (Created by the Author)

	Pedagogy/Education Model	Learning Theory	Features and Impacts on Space
Traditional Learning	Traditional Education Models	Behaviorism	- Classroom management, teacher-centered - Order of desks, emphasis on discipline - Rigid and symmetrical classrooms
		Cognitivism	- Focused on information processing - Individual work areas, quiet and organized spaces - Laboratories, libraries, study halls
New Generation Learning	Progressive Education Model	Constructivism, and Experiential Learning	- Experience and active learning - Teacher; guide and model - Flexible classes, project-oriented - Workshop, open-plan spaces
	Montessori and Reggio Emilia Pedagogies	Constructivism and Social Constructivism	- Student-centered, individual learning - Natural materials, home-like environments - Multifunctional, modular, flexible and individual&group work spaces
	Social Constructivist and Collaborative Pedagogies	Constructivism, Social Learning and Social Constructivism	- Group work and community learning - Social areas, collaborative work areas - Open and flexible spatial layout
	Digital Pedagogy, Education 4.0, Hybrid Learning	Constructivism, Social Constructivism, Connectivism and Technology-Supported Learning	- Technology-enhanced learning - Smart classrooms, VR/AR, online/hybrid spaces - Flexible, multi-purpose environments

as a whole. In Dovey's (2013) study, he drew on this theory to create plan diagrams of the relationship and clustering of learning spaces to each other, and represented these diagrams with codes according to the pedagogies he supported, as shown in Figure 6. From these diagrams, he coded the plans that allowed for traditional pedagogies as Type 1 and Type 2, and the spaces for student-centred learning as Type 3, Type 4 and Type 5. While he associated Type 1 and Type 2 with Foucault's (1980) theories of power, knowledge, authority and disciplinary perspectives, he associated the student-centred, new generation learning spaces, which he coded as Type 3, Type 4 and Type 5, with Deleuze & Guattari's (1987) open-control philosophy (Figure 6).

For his typology diagrams, Dovey (2013) later collaborated with Fisher (2014) to create a colour diagrammatic language scheme describing space types and connections. The typologies in numerical order (Type 1, Type 2, etc.) in Figure 6 were recoded with letters as Type A, Type B, Type C, Type D and Type E in the new study and they used these diagrams to analyse a number of innovative school plans. According to this method of analysis: Type A; completely traditional models, Type B; contemporary traditional models, Type C; models where classrooms can be combined for more pedagogical options, Type D; in

**Figure 6.** Typology diagrams of segmentarity (Dovey, 2013).

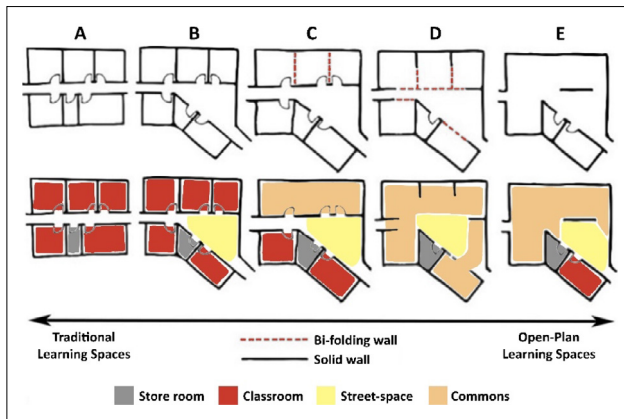


Figure 7. Plan diagrams of the typologies developed by Dovey & Fisher (2014) (Adapted from Soccio & Cleveland, 2015).

contrast to Type C, models where the transformed common space can open directly onto street-space areas, Type E; designed directly as a common space, specifically designed for new generation pedagogies. The method developed based on Dovey & Fisher's (2014) learning space typology plan diagrams in Figure 7 provides an analytical framework for understanding the pedagogies enabled by school plans, defining the typologies determined according to learning space configurations as traditional and new generation.

In addition to the physical characteristics of the space, the Assemblage theory also pays attention to the social interactions that take place in the space and the purposes of use. Therefore, the analysis of Gökçeada High School based on Assemblage theory, when evaluated the results alongside the data in Table 1 and Table 2, will enable us to concretely reveal the pedagogies supported in learning spaces and to understand how the space overlaps with learning.

THE SPATIAL CONFIGURATION OF GÖKÇEADA HIGH SCHOOL IN THE CONTEXT OF NEW GENERATION LEARNING

In 2014, the Çanakkale Provincial Special Administration announced that the existing educational buildings would be demolished due to earthquake risk and opened the

Gökçeada High School Campus Architectural Project Competition. Before the pre-selection, the organisers stated that they expected an innovative campus model from the competing teams that would be open to island residents in the context of 'lifelong learning' and would bring together educational buildings in common areas in the context of 'social learning' (Arkitera, 2014). In this context, the PAB Architecture team's project was deemed worthy of 1st prize. The first project selected was completed in the summer of 2019 and opened for use as of the 2019-2020 academic year (Arkitera, 2019). In line with the expectations of the competition organization, the main goal of the project is to ensure that the educational building and other social facilities of the campus have a strong relationship with the city centre and to integrate education and social life with urban life (PAB Architecture, n.d.).

The campus, which consists of a dormitory, a gym, a conference hall and a library with the educational building seen in Figure 8, has been designed as an open campus, considering the small scale of the island and the limited opportunities for the islanders to access social facilities. The social facilities of the campus, the square and open sports areas are aimed to be used by the islanders as well as the students, and thus to increase social interaction on the island (Arkitera, 2019).

As seen in Figure 9, thanks to being an integrated and open campus to the city, the units on the ground floor of the educational building are visually and physically accessible from the street and the courtyard allows the islanders to have a direct relationship with the building and to openly observe the artistic and scientific activities. This transparent and permeable fiction, especially on the multi-door ground floor where entrances and exits to each unit can be provided from any point, continues in the corridors of the campus. While the corridor has a direct relationship with the garden, the corridor and the classroom behind the corridor can be observed from the garden (Archdaily, 2020; TRT 2, 2023).

This study analyses the usage possibilities of all learning spaces, from classrooms to open spaces, within the context of new generation learning spaces on the Gökçeada High

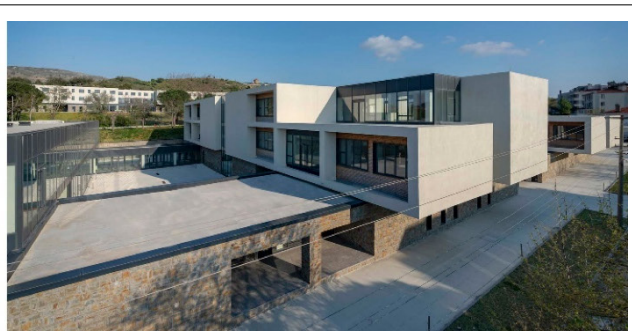


Figure 8. Gökçeada High School on the campus (Arkitera, 2019).

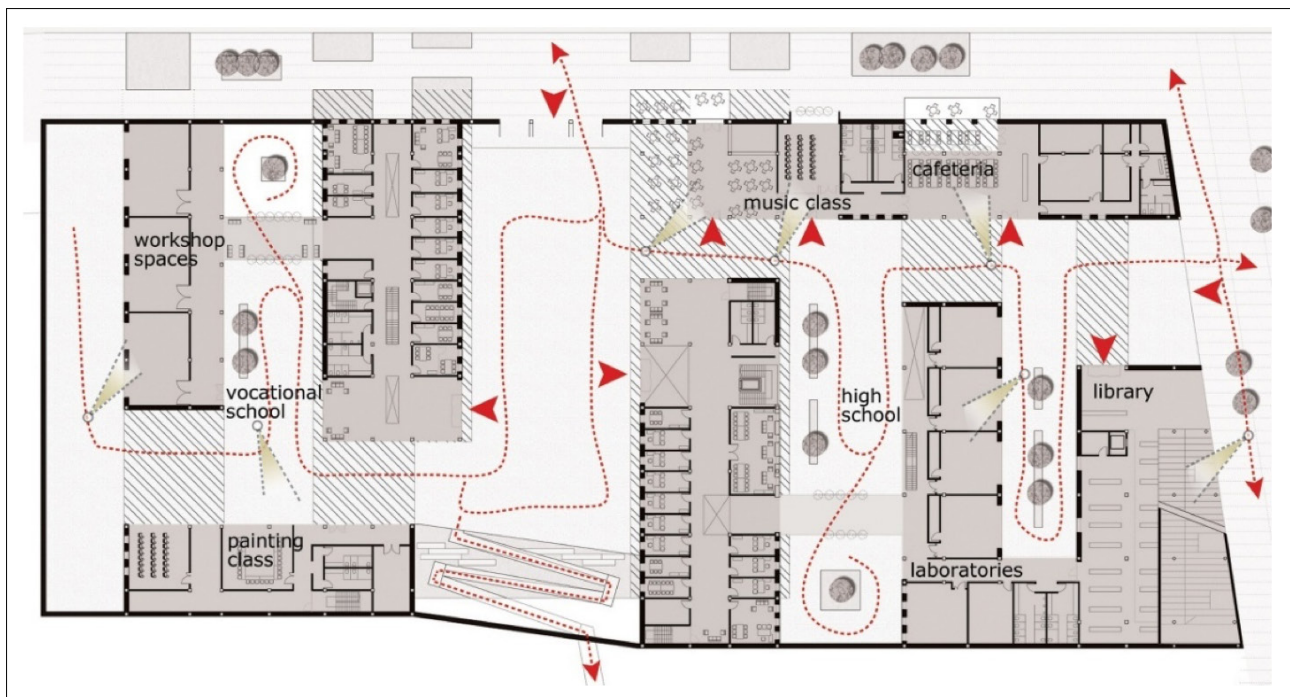


Figure 9. Flow diagram on the ground floor (Archdaily, 2020).

School Campus, which was implemented with the aim of being an innovative example. In the research, analyses were made based on the ground and first floor plans of the educational building on the campus (Arkitera, 2019). In the analyses made with the method based on the Assemblage theory, typologies of learning spaces were determined by reading the plans. The qualities of these typologies, which are shown in the plan diagrams in Figure 6 and Figure 7 mentioned in the method section, are explained in Table 3.

Within the scope of the study, the relationships and connections of the learning spaces were schematised according to the qualities listed in Table 3, and diagrams of the plans were drawn. These diagrams of the plans were used to determine which typology the learning spaces correspond to according to their clustering. Using this Assemblage theory-based method, (traditional or new

generation) learning models supported in the formal and informal learning spaces of Gökçeada High School were identified and demonstrated in a concrete way through a sample school. Additionally, the findings of the analysis were evaluated alongside the data obtained from the literature review on learning modes, learning theories and relations of pedagogy & space, and were interpreted in the context of new-generation learning.

According to the analysis and research on the ground floor: Due to the permeable and transparent organisation of the ground floor, the primary users, students and staff, as well as the local community, are active users. In addition to formal learning, there are spaces specifically designed for informal learning. Socialisation and collaboration are encouraged through this holistic design of formal and informal learning spaces (Arkitera, 2019).

Table 3. The typologies of learning spaces by Dovey & Fisher (2014)

Type A	It includes traditional classrooms that do not have direct access to other learning spaces, but are accessed only through an enclosed corridor or access area.
Type B	It is a contemporary traditional model with traditional classes accessed through street-space.
Type C	It is a model in which two or more traditional classrooms are converted into a single common space with movable partitions. It provides more pedagogical options than Type A and B. The transitional link between the merged classrooms and the street-space continues.
Type D	It is a model in which traditional clusters of classes can become a larger common space and can be separated and return to their former state. The common space transformed by the merged classes can be opened directly to the street-space and integrated into the street-space.
Type E	It is a special layout designed directly as a common space, which does not turn into a traditional classroom layout and includes spatial innovations. Although there is no return to the traditional model, a few traditional classrooms, meeting rooms, etc. can be added to the street-space or common space part.

The ground floor plan in Figure 10 shows that there are 3 classrooms, 1 painting workshop, 1 music workshop and 5 fixed classrooms (laboratories) for formal learning; 2 free workshops, 2 private common spaces, street-spaces for access to classrooms and outdoor spaces directly associated with the building and open to the public for informal learning (Arkitera, 2019).

Classrooms, laboratories and workshops, which are formal learning spaces, are characterised as 'closed' because their dividing elements are fixed walls and cannot be transformed; while free workshops, private common spaces and street-spaces are characterised as 'open' because they are editable and free spaces (Dovey & Fisher, 2014). 'Closed' classrooms accessed through 'closed' corridors with no direct access to other spaces correspond to the purely traditional Type A model; 'closed' classrooms accessed from the street-space correspond to the contemporary traditional Type B model; free workshops accessed from the street-space correspond to the Type C model as they offer more pedagogical options and are open to transformation. Private spaces designed directly as common spaces and for new generation pedagogies correspond to the Type E model and have the characteristics of new generation learning spaces. These learning spaces and diagrams within the ground floor diagram in Figure 11 are grouped according to Dovey & Fisher's (2014) typologies and shown in Figure 12.

When the diagrams are evaluated, it is determined that there are a total of 15 different learning spaces on the ground floor, 3 Type A, 8 Type B, 2 Type C and 2 Type E spaces. There are 4 different typologies of spaces, 2 traditional and 2 new generation.

According to the analysis and research on the first floor:

On the first floor, a plan is read with traditional classrooms arranged in rows, similar to the layout often found in educational buildings. The floor plan in Figure 13 shows that there are 25 classrooms where formal learning takes place, 4 common spaces designed as informal learning spaces, and galleries with visual connections to other floors (Arkitera, 2019).

Looking at the floor plan as a whole, the integrated fiction with the outdoor spaces on the ground floor continues on this floor with open and semi-open terraces accessed from the street-space. Again, as on the ground floor, some of the classrooms on the first floor are accessed from enclosed corridors and some from street-spaces (Figure 13).

'Closed' classrooms accessed from 'closed' corridors with no direct access to other spaces correspond to the purely traditional Type A model; 'Closed' classrooms accessed from the street-space correspond to the contemporary traditional Type B model. On the first floor, as on the ground floor, in addition to the formal learning spaces, there are alternative spaces for informal learning that allow for various meetings, individual or group work, and resting niches. These special spaces, which are designed directly as common spaces and for new generation pedagogies, correspond to the Type E model where new generation pedagogies are applied. The learning spaces in the diagram of the first floor in Figure 14 are grouped according to Dovey & Fisher's (2014) typology, as shown in Figure 15.

When the diagrams are evaluated, it is determined that there are 29 different learning spaces on the first floor, 5

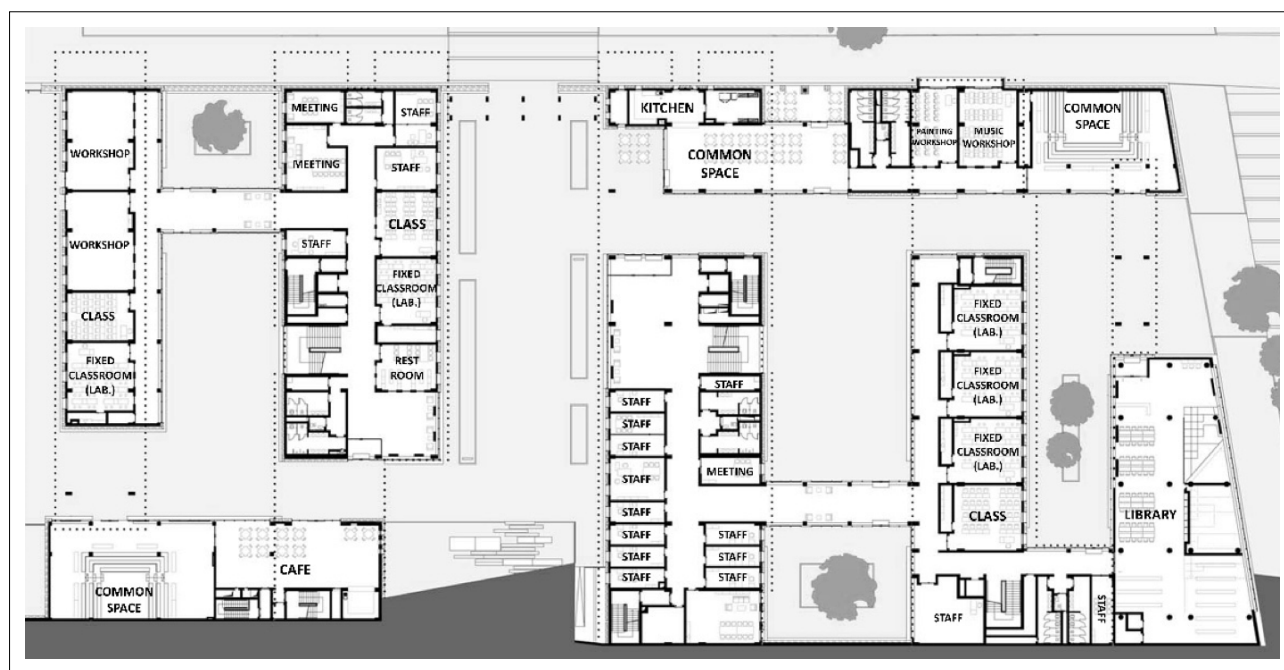


Figure 10. Ground floor plan (Adapted from Arkitera, 2019).

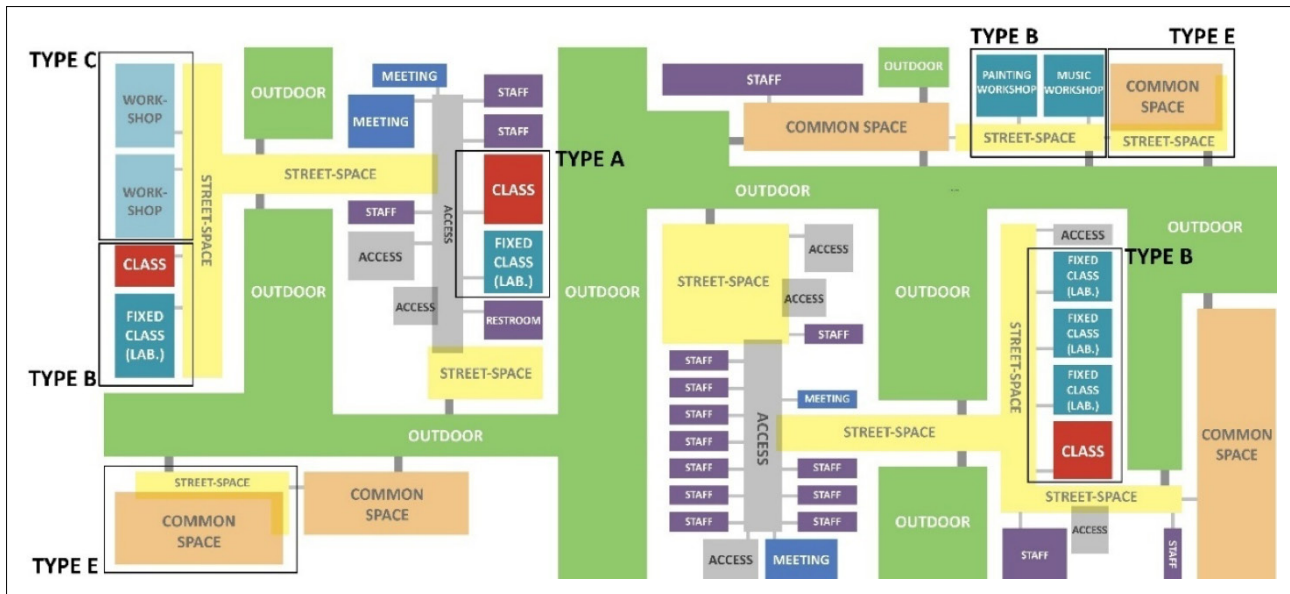


Figure 11. Ground floor diagram (Created by the Author).

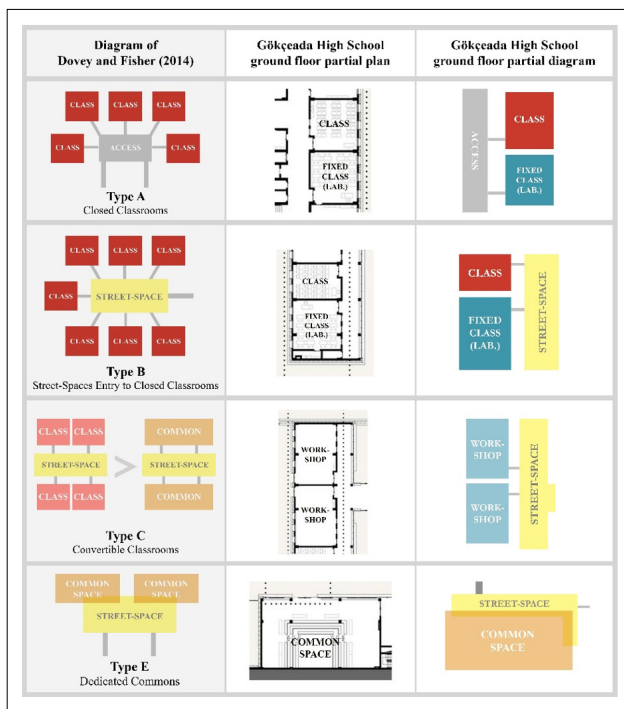


Figure 12. Diagram typologies on the ground floor (Created by the Author).

Type A, 20 Type B and 4 Type E spaces. There are 3 different typologies of spaces, 2 traditional and 1 new generation.

EVALUATIONS

The analysis of Gökçeada High School revealed the traditional and new generation typologies of learning spaces. The numerical and percentage distribution of the

traditional (Types A and B) and new-generation (Types C, D and E) typologies which are considered as the determining factors for learning approaches supported in spaces, has been determined within the building. These distributions shown in Tables 4 and Table 5 are the first step in evaluating the educational building in the context of new-generation learning, and are evaluated with the learning modes that the spaces host and the learning models they support.

As seen in Table 4, the analysis findings show that there are 14 different learning spaces on the ground floor, approximately 71% of which are traditional and approximately 29% of which are new generation. The ground floor classrooms, defined as Types A and B, were designed according to traditional educational models influenced by behaviourist and cognitive theories, as shown in Table 2. Nevertheless, it can be said that opening eight Type B spaces onto the street-space, which is an informal learning space instead of a closed corridor, the transparent design of the facades of the painting and music studios facing İnönü Street as seen in Figure 16, and the effort to increase social interaction by establishing visual connections with the corridor, and indirectly with the courtyard, through the windows of the classrooms, are all attempts to adapt the patterns of the traditional education model to today's conditions. In this way, although these spaces are defined as Type B, which is the contemporary traditional model, they do not conform to the norms of 'closed' formal learning spaces. Instead, they become part of the permeable and transparent fiction on the ground floor.

However, the formal learning spaces required for theoretical courses at high school level could be designed as flexible, next-generation learning spaces, such as Types C and D. These spaces would comprise larger areas that

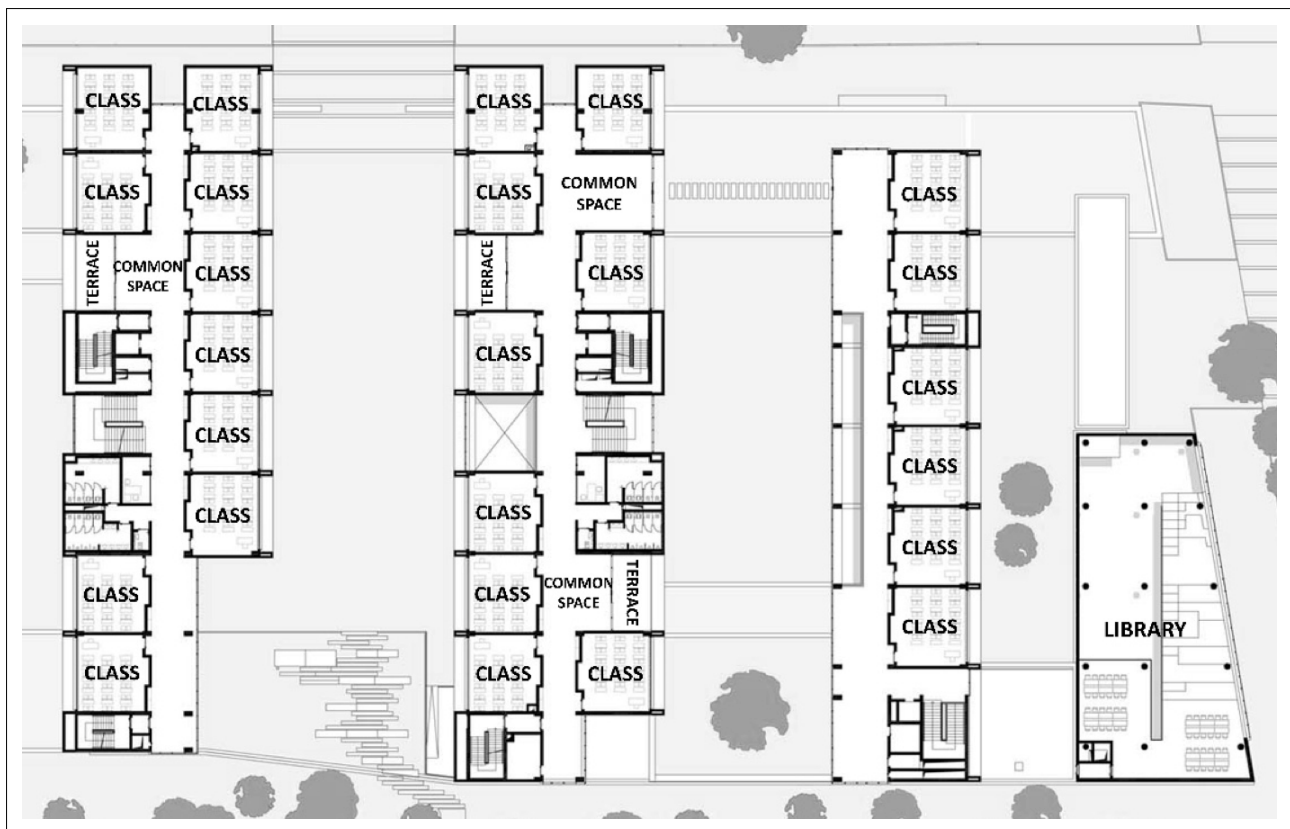


Figure 13. First floor plan (Adapted from Arkitera, 2019).

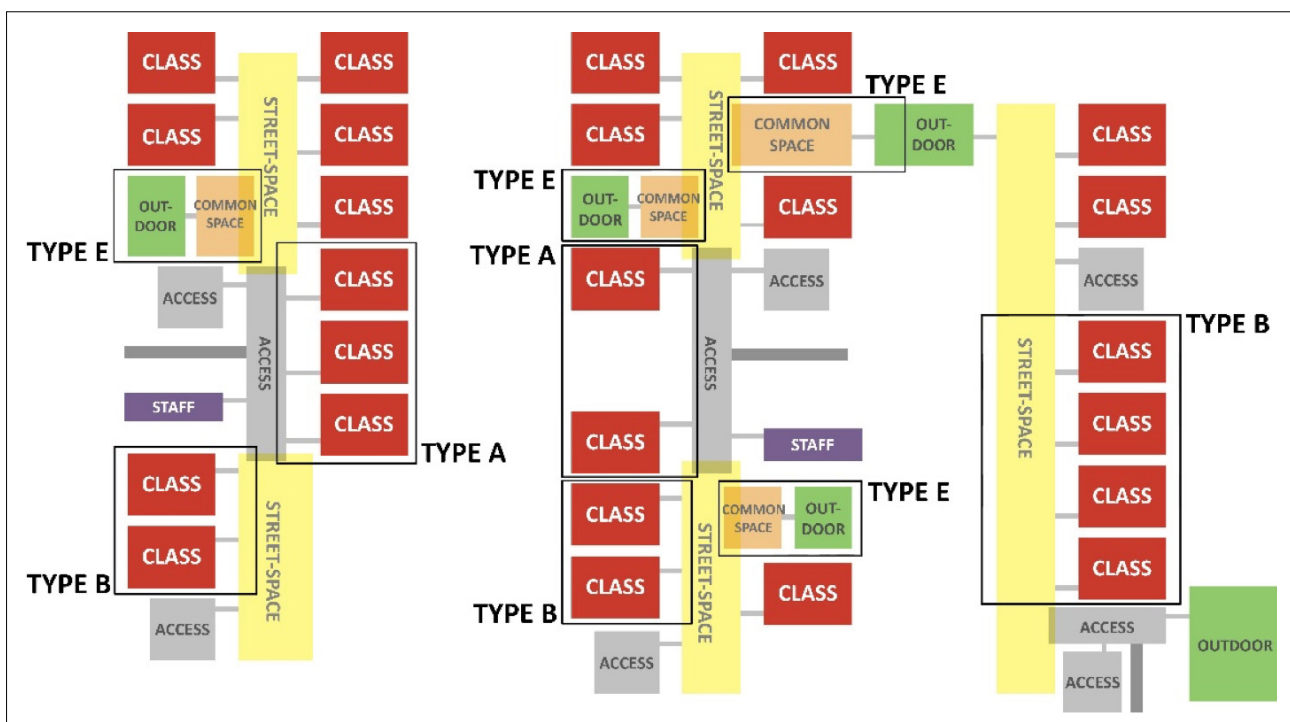


Figure 14. First floor diagram (Created by the Author).

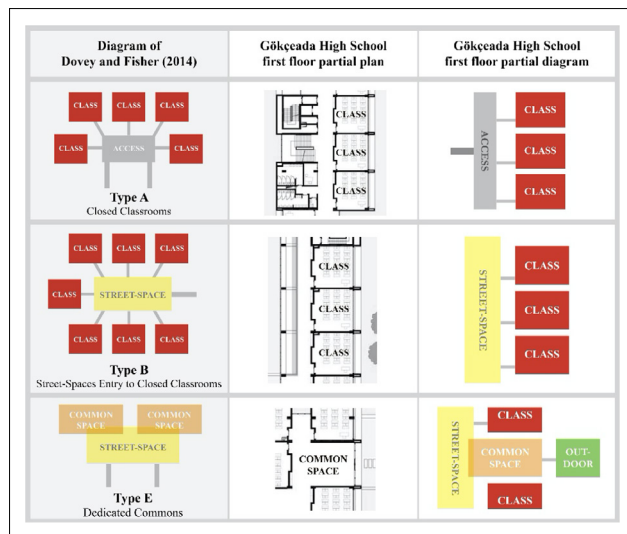


Figure 15. Diagram typologies on the first floor (Created by the Author).

can be divided into classrooms with movable dividing elements, which can be removed and rearranged according to different purposes, instead of closed classrooms, such as Types A and B. Type C and especially Type D, which is not included in the building, have the potential to transition between formal and informal, or to be structured as an integrated (formal & informal) space, allowing new generation pedagogies to be implemented. In this context, especially including Type D on the ground floor, integrated with the city, and having more Type C spaces could have brought the high school building closer to achieving its innovative educational goals. Type E, on the other hand, meets the need for informal learning spaces in line with new-generation learning approaches, such as social learning and social constructivism, providing common areas where students can come together within the building (Table 2).

As seen in Table 5, the analysis findings show that there are 29 different learning spaces on the first floor, approximately

86% are traditional and 14% are of the new generation. Compared to the ground floor layout, the first floor has slightly more traditional learning spaces and classes defined as Types A and B. The transparent and permeable ground floor layout, where interior and exterior spaces actively communicate with each other, continues on the upper floors in the form of an integrated learning layout where spaces intertwine, as shown in Figure 17. These informal learning spaces, which are the Type E typology, allow learning to continue outside the classroom.

There are no Types C and D on the first floor, but the first floor, like the ground floor, is suitable for designing flexible large areas such as Type C and Type D. Although Type E is given more space on this floor than on the ground floor, it is solved in small areas. The necessity for formal space could be met by dividing large areas, as opposed to the current arrangement of have been limited classes of the same size situated adjacent to one another. Furthermore, pedagogical opportunities could be diversified through the implementation of diverse configurations to cater to a range of requirements.

As with Gökçeada High School, the sample innovative high school plans examined by Dovey & Fisher (2014) also include spaces for both traditional and student-centred pedagogies. However, the findings of the present study indicate a clear preference among innovative schools for transformable spaces as an alternative to traditional classrooms or special open layouts. Therefore, they argued that a completely open plan, while allowing for the implementation of new generation pedagogies such as social constructivist and collaborative, is not ideal because the space cannot be transformed when needed for the implementation of traditional pedagogies. They emphasized the importance of architectural capacity for ‘transformability’ from one pedagogy to another, i.e. flexible spaces. These flexible spaces are defined by the Type C and Type D typologies. It is evident that the spatial

Table 4. Learning space typologies in the ground floor (Created by the Author)

	Traditional Learning Spaces		New Generation Learning Spaces		
	Type A	Type B	Type C	Type D	Type E
Ground Floor	2	8	2	-	2
% of Total Distribution	~71%		~29%		

Table 5. Learning space typologies in the first floor (Created by the Author)

	Traditional Learning Spaces		New Generation Learning Spaces		
	Type A	Type B	Type C	Type D	Type E
First Floor	5	20	-	-	4
% of Total Distribution	~86%		~14%		



Figure 16. The facade of the workshops on the İnönü Street side (Arkitera, 2019).

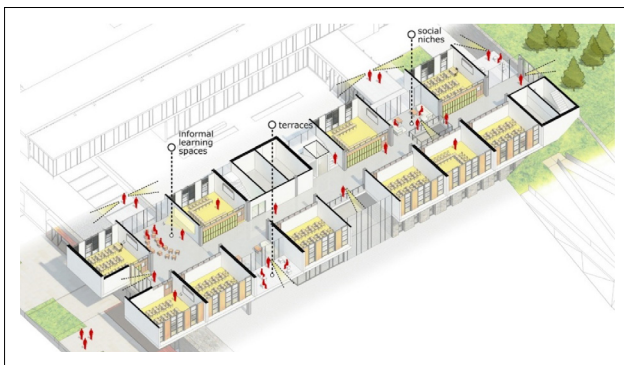


Figure 17. Common indoor learning spaces diagram (Archdaily, 2020).

configurations associated with the Type E model are not characterised by this degree of flexibility, as they are not 'transformable'. However, it is possible to implement new generation Type C and Type D models in terms of both economic and spatial transformation.

In the case of limited designs, where classes lack divergent usage possibilities, integrated learning and individual or group work environments can be designed with different types of furniture arrangements to accommodate formal and informal learning modes, as in the sample plan model of Byers et al. (2014). In addition, the integration of technology also plays an important role in the redesign

of learning spaces in the 21st-century. Spaces equipped with technological tools such as high-speed internet, computers, projectors and interactive boards can become more effective, innovative and student-centred. In this way, an environment can be created where students are actively involved, where interactive teaching is organised and where students can direct their own learning processes.

In parallel with the analysis made in the context of traditional-new generation in Gökçeada High School, the learning modes hosted by the learning spaces were also evaluated. The evaluation of the typologies and the learning modes it contains is shown in Table 6. The 'Type A' learning space does not include informal learning either in the classroom or in the corridors. Type B includes informal learning in the street-spaces outside the classroom and access to the classroom, but does not include integrated (formal & informal) learning. Non-formal learning, on the other hand, is not included in any of the typologies because it is not structurally included in the educational building, but is supported by informal learning in public social facilities on the campus.

The evaluation results in Table 6 shows that Type C and Type E, defined as new generation learning spaces, stand out for their integrated (formal & informal) learning fiction. These spaces are considered innovative according to 21st-century learning approaches. For this reason, as a

Table 6. Learning modes supported by the learning space typologies (Created by the Author)

	Ground Floor				First Floor		
	Type A	Type B	Type C	Type E	Type A	Type B	Type E
Formal	✓	✓	✓	✓	✓	✓	✓
Non-formal	-	-	-	-	-	-	-
Informal	-	✓	✓	✓	-	✓	✓
Integrated (Formal & Informal)	-	-	✓	✓	-	-	✓

result of the analyses and evaluations, although traditional learning spaces have a predominant percentage, it is seen that traditional and new generation spaces are designed together. The campus, designed to be open to the public to integrate education with social life, is integrated into urban life. With alternative learning spaces, from common spaces to outdoor spaces, and a transparent and participatory educational model, it supports students' formal education with informal learning at many points. In this context, the school is an exemplary model for the new generation, taking into account the relationship between space and users and taking initiatives towards the pedagogical potential of space.

CONCLUSION

Learning spaces are nourished by the theoretical framework of learning theories and take concrete forms through pedagogies. While space is seen as passive in traditional education models, new generation pedagogies recognise that learning is significantly shaped by its environment, and it is considered crucial for spaces to facilitate learning through social interaction and community engagement. The defined 21st-century skills and learning frameworks emphasise the need for these learning spaces to ensure that students become competent individuals in every field. As pedagogy and needs evolve, redesigned learning spaces continue to adapt as a support system in the education of individuals according to these frameworks. New-generation learning spaces that take contemporary needs and learning approaches into account are the result of this transformation. In this context, today's learning space is an important component of the educational ecosystem, acting as a third teacher.

This study presents a comprehensive research on how learning transforms space, and how the space transformed according to current needs supports learning. Gökçeada High School has been selected as a case study within the context of exploring the relationship between new generation learning and space. Gökçeada High School is a nationally significant example and is discussed in detail in the context of new generation learning. Analysing the possibilities of using Gökçeada High School's learning spaces in the context of new-generation learning shows that, although it does not have a completely new-generation educational building, the campus is designed to offer students a contemporary and effective learning experience. While the building contains mainly traditional learning spaces, it also provides environments where new generation pedagogies can be applied and different learning modes can be accommodated. In informal learning spaces, social interaction and collaborative learning are encouraged through special common areas designed for socialising and group work. The design of the physical area is also

considered important in achieving innovative educational goals on a campus scale. The open campus, integrated into the surrounding area as an extension of real life, enables the implementation of current understandings such as social constructivism and social learning. The public-facing and city-integrated structure of the campus is also a response to the need to prepare 21st-century individuals for future social realities. The campus structure allows students to communicate with their environment, realise their individual contributions to social life at all times and feel safe and included. As a result, the design of the space is part of the education, providing students with a quality learning experience and supporting both the social and academic development of students. As learning and education models evolve, spaces must be open to change and flexible enough to support new practices. Indeed, the space itself should be capable of playing a transformative role in education.

Using the Gökçeada High School Campus as an example, this study reveals the importance of new generation learning spaces by highlighting the effects of space on learning processes and its role in student motivation. By providing information on the current needs and solutions to problems in educational buildings, the study enables architectural designers to make more informed decisions on future projects. In addition, the inclusion of learning modes in the evaluation process of this study offers a new perspective to the discussions on the relationship between learning and space in the 21st-century. In future researches, new generation learning spaces can be analysed in the context of the relationship between 'indoor' and 'outdoor', and joint studies can be carried out with various disciplines related to education, such as psychology. Moreover, studies on current issues such as sustainability, inclusivity, and digitalisation, all of which play an important role in 21st-century learning, can contribute to the development of new-generation learning spaces.

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REFERENCES

- Archdaily. (2020). *Gökçeada High School Campus / PAB Architects*. Retrieved Sep 25, 2025, from <https://www.archdaily.com/932443/gokceada-high-school-campus-pab-architects>

- Arkitera. (2014). *Gökçeada High School Campus Architectural Project Competition Pre-Selection Specifications*. Retrieved Sep 25, 2025, from <https://www.arkitera.com/yarisma/gokceada-lise-kampusu-mi-mari-proje-yarismasi/>
- Arkitera. (2019). *Gökçeada High School Campus*. Retrieved Sep 25, 2025, from <https://www.arkitera.com/proje/gokceada-lise-kampusu/>
- Atabay, S. (2014). The effect of space and architecture on educational success. In B. Binat & N. Şık (Eds.), *VitrA Contemporary Architecture Series 3 Educational Buildings* (pp. 36–40).
- Aydın, C. H. (2011). *The perspective of open and distance learning student candidates*. Pegem Academy Publications.
- Brooks, D. C. (2012). Space and consequences: The impact of different formal learning spaces on instructor and student behavior. *Journal of Learning Spaces*, 1(2), 282.
- Brown, M., & Long, P. (2006). Trends in learning space design. In D. G. Oblinger (Ed.), *Learning Spaces* (pp. 9.1–9.11).
- Bruner, J. (1966). *Toward a theory of instruction*. Harvard University Press.
- Burke, C., & Grosvenor, I. (2008). *School*. Reaktion Books.
- Byers, T., Imms, W., & Hartnell-Young, E. (2014). Making the case for space: The effect of learning spaces on teaching and learning. *Curriculum and Teaching*, 29(1), 5–19. <https://doi.org/10.7459/ct/29.1.02>
- Chand, S. P. (2024). Constructivism in education: Exploring the contributions of Piaget, Vygotsky, and Bruner. *International Journal of Science and Research*, 12(7), 274–278. <https://doi.org/10.21275/SR23630021800>
- Çiftçi, S., Yayla, A., & Sağlam, A. (2021). 21st-century skills in the context of students, teachers, and educational environments. *RumeliDE Journal of Language and Literature Studies*, (24), 718–734. <https://doi.org/10.29000/rumelide.995863>
- Danielle Colardyn, J. B. (2004). Validation of formal, non-formal, and informal learning: Policy and practices in EU member states. *European Journal of Education*, 39(1), 69–89. <https://doi.org/10.1111/j.0141-8211.2004.00167.x>
- Deleuze, G., & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. University of Minnesota Press.
- Dib, C. Z. (1988). Formal, non-formal and informal education: Concepts/applicability. *Cooperative Networks in Physics Education*, (173), 300–315. <https://doi.org/10.1063/1.37526>
- Dovey, K. (2013). Assembling architecture. In H. Frichot & S. Loo (Eds.), *Deleuze and Architecture* (pp. 131–148).
- Dovey, K., & Fisher, K. (2014). Designing for adaptation: The school as socio-spatial assemblage. *Journal of Architecture*, 19(1), 43–63. <https://doi.org/10.1080/13602365.2014.882376>
- Driscoll, M. (2005). *Psychology of learning for instruction*. Pearson.
- Edwards, C. (2011). Teacher and learner, partner and guide: The role of the teacher. In C. Edwards, L. Gandini, & G. Forman (Eds.), *The Hundred Languages of Children: The Reggio Emilia Experience in Transformation* (pp. 1–23). <https://doi.org/10.5040/9798400667664>
- Eрман, O., & Gümüşburun Ayalp, G. (2022). Reflection of learning theories on the architecture of school buildings. In S. Al Şensoy (Ed.), *Educational Buildings and Design* (3rd ed., pp. 53–76). Pegem Academy Publications.
- Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of Science Education and Technology*, 16(2), 171–190. <https://doi.org/10.1007/s10956-006-9027-1>
- Fisher, K. (2005). Research into identifying effective learning environments. *Evaluating Quality in Educational Facilities*, 9, 159–167.
- Foucault, M. (1980). *Power/knowledge: Selected interviews and other writings*. Pantheon Books.
- Göksoy, B. (2021). *Model proposal for understanding pedagogical and spatial configuration in educational buildings* [Master's Thesis]. Süleyman Demirel University.
- Güzer, C. A. (2014). Educational buildings as a medium of conflict and continuity between globalism and locality. In B. Binat & N. Şık (Eds.), *VitrA Contemporary Architecture Series 3 Educational Buildings* (pp. 28–31).
- Imms, W., Cleveland, B., & Fisher, K. E. (2016). *Evaluating learning environments: Snapshots of emerging issues, methods and knowledge*. Sense Publishing. <https://doi.org/10.1007/978-94-6300-537-1>
- Imms, W., Mahat, M., Byers, T., & Murphy, D. (2017). Type and use of innovative learning environments in Australasian schools ILETC survey 1. LEARN.
- Laurillard, D. (2012). *Teaching as a design science: Building pedagogical patterns for learning and technology*. Routledge.
- Lippman, P. C. (2010). *Evidence-based design of elementary and secondary schools*. John Wiley.
- Mahat, M., Bradbeer, C., Byers, T., & Imms, W. (2018). Innovative learning environments and teacher change: Defining key concepts. LEARN.
- Nair, P., Fielding, R., & Lackney, J. A. (2009). *The language of school design: Design patterns for 21st century schools*. Designshare.
- Oblinger, D. G. (Ed.). (2006). *Learning spaces*. EDUCAUSE.
- OECD. (2013). *Innovative learning environments, educational research and innovation*. OECD Publishing.

- Olugbenga, M. (2021). The relationship between learning theories and progressive education. *International Journal of Research Publication and Reviews*, 2(12), 421–424.
- Ormrod, J. E. (2011). *Human learning*. Pearson Publishing.
- PAB Architecture. (n.d.). Gökçeada High School Campus. Retrieved March 15, 2024, from <https://www.pab.com.tr/gokceada-lise-kampusu>
- Petrova, M. N., Elizondo, B. S., & Méndez, D. G. G. (2022). Creative strategies for the learning spaces of the future. *Academic Press*. <https://doi.org/10.26530/9789401496476-013>
- Piaget, J. (1950). *The psychology of intelligence*. Routledge.
- Schunk, D. (2020). *Learning theories: An educational perspective*. Macmillan Publishing.
- Shah, R. K. (2021). Conceptualizing and defining pedagogy. *IOSR Journal of Research & Method in Education*, 11(1), 6–29. <https://doi.org/10.9790/7388-1101020629>
- Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning*, 2(1), article1. https://www.itdl.org/Journal/Jan_05/article01.htm
- Soccio, P., & Cleveland, B. (2015). Study 1: Towards effective learning environments: An evidence-based approach [Unpublished Report]. The University of Melbourne.
- Tang, C. (2020). New generation learning spaces: Ideals and planning. *School Administrators*, (128), 1–18. [https://doi.org/10.6423/HHHC.202007_\(128\).0001](https://doi.org/10.6423/HHHC.202007_(128).0001)
- Taylor, A. (2009). *Linking architecture and education*. University of New Mexico Press.
- TRT 2. (2023, October 10). *Gökçeada High School Campus | Eşik 19th Episode @trt2* [Video]. YouTube. https://www.youtube.com/watch?v=2_BUZwwR2E0
- Tusting, K., & Barton, D. (2013). *A review on learning theories and adult learning models*. [Translated by A. Demirli & A. Yıldız]. Dipnot.
- Woolner, P. (2010). *The design of learning spaces*. Continuum.



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M G A R O N

Article

An evaluation of rural policies and approaches in Türkiye in the planned period within the scope of quality of life

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ABSTRACT

Rural policies and approaches shape the physical, economic, social, and environmental dimensions of rural life. When well-designed and implemented, they lead to improved living standards, greater opportunities, and sustainable development, all of which are core components of quality of life. Since the founding of the Republic, Türkiye has developed numerous policies and approaches to address rural settlements. However, comparative analyses examining these policies and their impact on the quality of life in rural areas remain scarce in the existing literature. In this regard, this study investigates Türkiye's rural settlement policies and approaches during the Planned Period (1963–present) through the lens of quality of life. It does so by assessing the extent to which these policies incorporate quality of life aspects, identifying areas that have been addressed and those that have been neglected, and offering insights for future policy development. To this end, the study conducts a comprehensive review of relevant literature and policy documents, offers a comparative evaluation of rural policies in the context of quality of life, and discusses the findings to support the formulation of future approaches. The key recommendations of this research include: (1) clearly defining the tools and mechanisms for implementing policy strategies; (2) increasing the state's role in developing new approaches and applications for rural settlements; (3) addressing each settlement's unique priorities for sustainable development; and (4) holistically evaluating the multiple dimensions comprising rural quality of life.

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INTRODUCTION

Rural settlements constitute a significant component of national economies, particularly due to their natural resource potential, raw materials, and food production capacity. Türkiye possesses distinct rural potentials due to its diverse geography and favorable climatic conditions. Although

certain rural development policies have been incorporated into national development plans, both the rural population and agricultural production have been gradually declining. The prioritization of urban centers and metropolitan areas in national economic policies and investment strategies has further widened the disparity in living standards between

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rural and urban areas, thereby accelerating rural-to-urban migration (Eminaoglu & Çevik, 2005; Taş, 2016; Açmaz Özden & Özden, 2019). As indicated by the United Nations (2002) and the State Planning Organization (DPT, 2007a), the average age in rural settlements is rising, particularly due to the migration of younger populations to urban areas. This phenomenon leads to the disruption of basic services, and the decline in agriculture threatens the sustainability of these settlements. On the other hand, the increasing influx of population into cities leads to reduced employment opportunities, strains on public service efficiency, and a deterioration in overall social cohesion in urban areas. Moreover, as noted by Yenigül (2016), the growing phenomenon of urban sprawl and the escalating impacts of climate change on agriculture have brought food security to the forefront of global concerns. Given the interrelated nature of these processes, it is inevitable that challenges encountered in rural areas will have a significant impact on urban centers in the future. Therefore, the policies and approaches developed for rural settlements play a pivotal role in shaping the broader future of countries.

The quality of life in rural settlements is a critical determinant in curbing rural-to-urban migration and ensuring the retention of rural populations within their communities. Consequently, international rural development policies over recent decades have underscored the importance of adopting a holistic approach to quality of life in policy formulation to achieve sustainable development in rural areas. However, rural policies in Türkiye have yet to comprehensively address all dimensions of quality of life within this integrated approach.

Within the framework of these issues, this study aims to achieve three primary objectives: first, to elucidate the quality of life in rural settlements along with its dimensions; second, to explore the relationship between rural policies and the quality of life; and third, to examine the rural development policies and approaches in Türkiye during the Planned Period, in order to evaluate the extent to which these have influenced various dimensions of quality of life—whether positively or negatively—by comparing their effectiveness, shortcomings, or overall contribution to improving rural living conditions. The ultimate goal is to provide insights that can guide the development of new approaches and contribute to the formulation of future policies and practices concerning rural settlements.

METHODOLOGY

In alignment with the issues and scope outlined in the introduction, this study seeks to answer the following research questions:

1. What are the dimensions that constitute the quality of life in rural settlements?

2. What is the theoretical relationship between rural policies and quality of life?
3. Which dimensions and indicators of quality of life in rural settlements are addressed by the policies and approaches developed for rural settlements in Türkiye during the Planned Period?
4. What directions can be proposed for the formulation of future policies and approaches within the framework of quality of life in rural settlements?

In responding to these specified questions, the research comprises a three-phase methodology:

1. literature and document analysis,
2. content analysis,
3. comparison of parameters for different approaches through tables (Figure 1).

In the third section, the concept and dimensions of quality of life in rural settlements are first examined, followed by a discussion of the theoretical relationship between rural policies and quality of life. To identify the relevant dimensions, a document analysis was conducted based on international organizations' quality of life measurement frameworks, such as the *Eurostat Quality of Life* (2015), the OECD's *How's Life?: Measuring Well-Being* (2011), and the *WHOQOL Measuring Quality of Life* (1997). In addition, academic studies by Kolodinsky et al. (2013), Michalska-Żyła & Marks-Krzyszowska (2018), Wiesli et al. (2021), and Küçükogul & Türkoğlu (2021) were reviewed. Based on these sources, a content analysis was conducted to identify frequently cited indicators, which were then systematically grouped into economic, technical infrastructure, social infrastructure, environmental, and institutional dimensions, conceptualized within the framework of this study.

Subsequently, policy documents of international organizations—including *Reaching the Rural Poor: A Renewed Strategy for Rural Development* (World Bank, 2003), *Scaling-Up the Impact of Good Practices in Rural Development: A Working Paper to Support Implementation of the World Bank's Rural Development Strategy* (World Bank, 2010), *Support for Rural Development by the European Agricultural Fund for Rural Development*

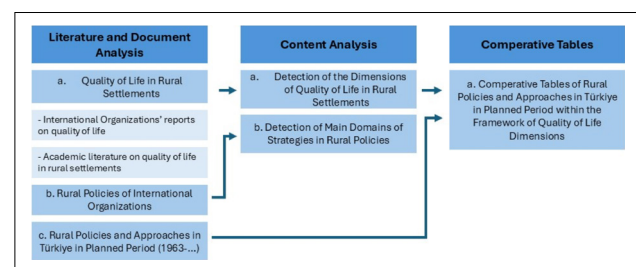


Figure 1. Methodology of research.

(European Commission, 2013), *Megatrends: Building Better Futures for Regions, Cities and Rural Areas* (OECD, 2019), and the *Sustainable Development Goals* (United Nations, 2023)—were analyzed to relate the strategic approaches to the identified dimensions of quality of life. In addition to the policy analysis, concrete examples from various countries, including Sweden, Ireland, Finland, Germany, and Italy, were briefly examined to further contextualize the discussion on rural settlement policies and their relationship with the dimensions of quality of life.

In Section Four, the evolution of rural settlement policies in Türkiye from the founding of the Republic to the present day was examined, with a focus on the Planned Period, a key era that marked the global integration of quality of life into development discourse and the national initiation of long-term development planning. To examine the relevant policies and approaches, a literature and document analysis was conducted using a range of sources, including academic publications, national theses, books, legislative texts, and official documents such as development plans, strategic frameworks, and action plans.

In the *Discussion and Conclusion* section, the dimensions of quality of life and Türkiye's rural settlement policies were jointly examined. Comparative tables were used to highlight key findings and to identify commonly addressed and overlooked issues. These tables also supported the evaluation of the effectiveness of the policies and approaches in enhancing the quality of life in rural settlements. For this evaluation, the OECD's *Applying Evaluation Criteria Thoughtfully* (2021) framework—specifically developed as a comprehensive tool for assessing development-related policies, strategies, and interventions—was utilized. Although the OECD framework proposes six evaluation criteria, it encourages context-specific selection depending on the study's focus. Accordingly, four criteria—**relevance**, **coherence**, **effectiveness**, and **sustainability**—were used in this study, as they were the most applicable and assessable within its framework. To guide the evaluation process from the perspective of rural quality of life, the following questions were formulated for each criterion:

- **Relevance:** Did the rural policies and approaches include appropriate interventions in terms of quality of life?
- **Coherence:** Were the strategies embedded within the policies and approaches coherent and well-aligned with other policies to improve rural quality of life?
- **Effectiveness:** When considered in the context of quality of life, have the implementations achieved their objectives?
- **Sustainability:** Have the rural policies, approaches, and their effects been maintained and continued over time?

Since obtaining quantitative results for each approach or policy requires a more detailed, data-driven study, the evaluation carried out in this study was descriptive. It relied solely on responses to the formulated questions, assessing each policy's alignment with the selected evaluation criteria in relation to quality of life in rural settlements, focusing on content and implementation aspects rather than measurable numerical outcomes.

Based on these analyses, the *Discussion and Conclusion* section presents comprehensive recommendations for future rural settlement policies, highlighting key factors and challenges to improve quality of life, as a major outcome of the study.

QUALITY OF LIFE IN RURAL SETTLEMENTS

The discourse on quality of life within a global context first emerged during the 1920s. By the 1960s, the concept was being examined in relation to national development, particularly in the United States. Beginning in the 1990s, the scope of quality of life broadened significantly, consequently becoming a pivotal theme in both national and international policy agendas. This evolution occurred concomitantly with the increasing interest in concepts such as sustainability, livability, smart growth, and resilience.

In recent years, with the rise of the information age, the rapid advancement of information technologies, transportation systems, production methods, and services, the concept of quality of life has gained even greater importance. This growing emphasis has been reflected in the agendas of international organizations and has also expanded academic research, highlighting the topic's global significance.

The quality of life of individuals is significantly influenced by the characteristics of the settlement in which they reside. In this context, especially with the increasing focus on rural development, there has been a notable surge in global research on quality of life in rural areas. It is emphasized in almost all international policies on rural settlements that the quality of life in rural settlements should be improved; accordingly, new strategies have been developed and continue to be implemented to advance this agenda.

However, in Türkiye, the concept of quality of life is predominantly addressed within the urban context, and studies focusing on quality of life in rural settlements remain relatively limited. This situation highlights the necessity to prioritize enhancing quality of life in rural settlements and expanding related research in Türkiye's academic literature, along with other critical aspects of rural development.

In this context, the study examines the approaches and policies concerning rural settlements in Türkiye—particularly during the Planned Period—with a focus on

quality of life, aiming to identify the dimensions that require improvement for the future. For this purpose, the following sections first address the definition and dimensions of quality of life in rural settlements and then explore its relationship with rural policies.

Definition and the Dimensions of Quality of Life in Rural Settlements

The most basic definition of quality of life refers to the degree of an individual's satisfaction with their living environment and standards. Scholars emphasize that there is no universally accepted definition of quality of life (Sarı & Kindap, 2018), and the term is often used interchangeably with concepts such as “well-being,” “life satisfaction,” “happiness,” and “livability.”

Quality of life is often discussed in relation to economic welfare in various studies. However, scholars such as Nussbaum & Sen (1993), Gregory et al. (2009), and Brauer & Dymitrow (2014) emphasize that the economy is not the sole determinant of quality of life. They contend that factors such as the natural and built environment, physical and psychological health, education, leisure and recreational activities, and the social environment also play a significant role in shaping quality of life.

As the topic is more frequently discussed in urban contexts, the study begins by examining urban quality of life, although the influencing factors may differ in rural settlements. Geray (1974) defines urban quality of life through the adequacy of infrastructure, services, and amenities across social, economic, and spatial dimensions. The Specialized Commission Report on Urban Quality of Life (T.C. Kalkınma Bakanlığı, 2018) links it to residents' rights, equitable service access, and satisfaction, emphasizing policies that support justice, accessibility, locality, and participation. While the scale and context differ from urban environments, these principles remain relevant for enhancing quality of life in rural areas.

Rural settlements encounter more significant challenges related to quality of life than urban areas due to harsher geographical and climatic conditions, limited employment opportunities, demographic factors, and insufficient government investments (Wardenburg & Brenner, 2020). Their small size and low population density make the provision of public services more difficult and costly (Bukenya et al., 2003), contributing to lower living standards and driving rural-to-urban migration (Dissart & Deller, 2000; Üçdoruk, 2002).

Quality of life indicators are widely discussed in both academic literature and reports by international organizations. However, their definitions often vary depending on the context. To address this variability, the study conducted a content analysis to identify and thematically group commonly used indicators into broader dimensions, forming a new framework for assessing rural

quality of life. This framework was then applied to examine rural policies in Türkiye. Table 1 presents the indicators used by various international organizations to evaluate quality of life, while Table 2 summarizes the indicators identified in academic studies that focus on rural settlements. All of these indicators were considered during the literature and document analysis for this study.

While many indicators have been used to assess rural quality of life, this study offers a new classification based on content analysis of academic and international sources. Based on this methodological framework, quality of life indicators in rural settlements are categorized into five dimensions: economic, technical infrastructure, social infrastructure, environmental, and institutional dimensions (Table 3). It should be noted that indicators related to individual characteristics—such as age, health status, etc.—were excluded from the scope of this study to maintain focus on structural and contextual dimensions of rural quality of life.

Table 1. Indicators used by international organizations to evaluate quality of life

International Organization and Name of the Study	Indicators
Eurostat Quality of Life (2015)	1- Material Living Conditions 2- Employment 3- Education 4- Health 5- Leisure and social interactions 6- Economic and Physical Safety 7- Governance and Basic Rights 8- Natural and Living Environment 9- Overall Life Satisfaction
OECD How's Life?: Measuring Well-Being (2011)	1- Health Status 2- Work and Life Balance 3- Education and Skills 4- Social Connections 5- Civic Engagement and Governance 6- Environmental Quality 7- Personal Security 8- Subjective Well-Being
WHOQOL Measuring Quality of Life (1997)	1- Physical Health 2- Psychological Health 3- Level of Independence 4- Social Relationships 5- Environment 6- Spirituality / Religion / Personal Beliefs

Table 2. Content analysis of academic literature on quality of life indicators in rural settlements

Author	Indicators
Kolodinsky et al., 2013	1- Mobility 2- Infrastructure 3- Perceptions of Safety 4- Social Networking 5- Age 6- Weather
Michalska-Żyła & Marks-Krzyszowska, 2018	1- Functioning of Health Care Institutions 2- Functioning of Educational Institutions in the Commune 3- Functioning of Cultural and Entertainment Institutions 4- Quality of the Environment 5- Possibility of Doing Business in the Commune 6- State of Roads in the Commune 7- Cleanliness of Public Places 8- Activities of the Local Parish and Priests 9- Assortment of Local Shops 10- Conditions for Rest and Recreation in the Commune 11- Transport Links in the Commune 12- Management of the Commune 13- Functioning of the Local Government 14- Activity of Political Parties in the Commune 15- Activity of Non-governmental Organizations in the Commune 16- Possibility of Influencing Important Issues in the Commune 17- State of Safety in the Place of Residence
Wiesli et al., 2021	1- Social Relations and Equality 2- Nature and Landscape 3- Education and Knowledge 4- Living 5- Participation, Identification, and Collective Emotions 6- Mobility 7- Health and Safety 8- Leisure and Recreation 9- Income and Employment
Küçükoğlu & Türkoğlu, 2021	1- Identity and Sense of Belonging 2- Landscape Character and Harmony 3- Settlement Pattern and Coherence 4- Street Pattern and Walkability 5- Open Spaces and Squares 6- Buildings and Interaction 7- Employment and Local Economy 8- Services and Amenities 9- Infrastructure, Maintenance, and Restoration 10- Social Structure 11- Participation and Decision-Making

Table 3. Organization of quality of life indicators extracted from literature and document analysis according to dimensions

Dimensions	Indicators Extracted from Document and Literature Analysis
Economic	Employment
	Income
	Local Economy
	Possibility of Doing Business
	Assortment of Local Shops
	Work and Life Balance
	Material Living Conditions
	Economic Safety
Technical Infrastructure	Infrastructure, Maintenance, and Restoration
	Mobility and Transportation
	Buildings and Interaction
Social Infrastructure	Education, Knowledge and Skills Health
	Social Networking and Connections
	Leisure, Cultural and Social Interactions
	Recreation
	Social Relations and Equality
	Identity and Sense of Belonging
Environmental	Social Structure
	Natural and Living Environment
	Environmental Quality
	Weather
Institutional	Physical Safety
	Governance and Basic Rights
	Participation and Decision-Making
	Activity of Political Parties and Non-governmental Organizations

These dimensions offer a holistic perspective on rural quality of life, enabling the organization of numerous sub-indicators within a coherent and unified structure. Subsequent subsections provide concise explanations of how each dimension influences quality of life in rural contexts.

• Economic Dimension

The economic dimension includes indicators such as income, employment opportunities based on the local economy and sector diversity, as well as material living conditions. In the current context, a decline in global agricultural production, also observed in Türkiye, has led to reduced economic vitality in rural areas, driven by global conditions and national sectoral policies (Küçüköğül & Türkoğlu, 2021). Small-scale producers are particularly affected, experiencing financial difficulties that reduce

their quality of life. Rising costs, falling profits, and youth migration further reduce the rural labor force and living standards (Wojewódzka-Wiewiórska et al., 2019). Moreover, landless rural populations also face economic insecurity due to limited capital (Rybakovas, 2016). Limited economic development also results in unemployment, particularly among the educated, while restricted access to consumer goods and dependence on urban centers for basic needs further reduce rural quality of life (Malkina-Pykh & Pykh, 2008).

• Technical Infrastructure Dimension

The technical infrastructure dimension includes transportation and communication systems, essential utilities, adequate housing, and technologies that support economic activity. In rural areas, low population density limits public transportation, especially in remote settlements, making private vehicle ownership essential and costly (Küçüköğül & Türkoğlu, 2021; Wojewódzka-Wiewiórska et al., 2019). Dülger Türkoğlu et al. (2008) point out that limited transportation options complicate commuting for work or education and reduce leisure time. Additionally, individuals without private vehicles experience mobility constraints, significantly lowering quality of life.

Deficiencies in basic infrastructure such as clean water, sewage, electricity, gas, and communication substantially affect well-being and contribute to environmental degradation.

In today's information age, internet access and tech skills are crucial. Koutsouris & Darnhofer (2010) points out that the lack of adequate infrastructure and digital literacy in rural settlements creates a digital divide, leading to social inequalities in education and connectivity, and economic disadvantages such as limited market access, reduced competitiveness, and slower technological adaptation.

Housing conditions also play a significant role in rural quality of life. Poor construction materials, inadequate heating/cooling systems, lack of planning, and weak resilience to natural disasters reduce housing comfort and, in turn, the quality of life.

• Social Infrastructure Dimension

The social infrastructure dimension encompasses access to education, healthcare, public facilities, and cultural or recreational services. In rural areas, low population density limits public investment, restricting access to social services and lowering quality of life.

Education is a key factor, yet schools are often closed or not established due to insufficient student numbers, forcing students to commute or drop out—negatively impacting both present and future quality of life. Similarly, limited healthcare infrastructure makes rural populations dependent on distant services, even for emergencies.

According to Wiesli et al. (2021), recreational and cultural leisure activities play an important role in individuals' social lives and personal development, and thus their overall quality of life. The lack of venues for cultural and recreational activities negatively impacts workforce reproduction, hinders stress relief through engaging in diverse pastimes, and lowers quality of life.

The need to travel for essential services also highlights rural mobility challenges. As noted by Michalska-Żyła & Marks-Krzyszowska (2018), the availability of nearby services significantly influences individuals' perception of their place of residence as attractive, which is closely tied to their overall quality of life.

• Environmental Dimension

The environmental dimension covers climate, geographical conditions, and natural disasters, and the state of natural resources. Harsh climate and geographical conditions in rural environments significantly impact quality of life. Since rural settlements are predominantly undeveloped and surrounded by natural environments, they are more vulnerable to natural disasters. The inadequacy of infrastructure and services to withstand such disasters renders rural settlements less resilient, creating a disadvantage in terms of quality of life.

Inadequate infrastructure and lack of modern technologies in sectors like agriculture and livestock also harm environmental quality. Problems such as uncontrolled waste disposal and lack of recycling lead to soil and water pollution, degrading the rural environment. Since rural populations are more closely connected to nature, environmental degradation affects them both economically and psychologically (Vaishar & Statsna, 2019). Additionally, urban expansion into rural areas also leads to gradual alteration, pollution, or destruction of natural rural spaces, indirectly impacting rural quality of life.

• Institutional Dimension

The institutional dimension includes indicators such as participation, voting rights, decision-making processes, transparency, and the responsibilities of various actors and institutions over rural settlements.

Local residents' ability to engage in decision-making through democratic mechanisms significantly shapes rural quality of life (Beslerová & Dzuričková, 2014; Wiesli et al., 2021). In this context, transparent and accountable local governance, along with trust in local authorities, plays a critical role.

Decisions made by central governments are equally important in determining rural living conditions. As Yenigül (2016) explains, urbanization policies that support the expansion of cities transform rural land into a commodity. Natural and agricultural areas are undergoing reclassification as urban land through zoning changes and

infrastructure development. In response to these rent-driven pressures, rural residents may choose to sell their land and migrate to urban areas due to the higher economic returns. Those who remain may encounter social tension as they try to maintain their way of life in the face of changing rural landscapes. Plans and projects driven by speculative interests lead to the disorganized and uncontrolled transformation of rural settlements, reshaping their social, economic, and physical identities. These developments often contribute to a broader decline in environmental and overall quality of life.

When examined holistically, it becomes evident that the dimensions of rural quality of life are deeply interconnected. Negative conditions in one dimension can trigger adverse effects in others, thereby influencing the overall well-being of rural residents. In this context, the following section discusses rural policies and their relationship with quality of life.

Relationship Between Rural Policies-Approaches and Quality of Life in Rural Settlements

The multidimensional nature of quality of life in rural settlements necessitates a comprehensive approach to policy design, in which rural policies and development strategies play a central role in enhancing overall well-being. This section examines how international policy frameworks reflect and align with these dimensions. These frameworks commonly address several interrelated areas, including the following (WB, 2003; WB, 2010; EC, 2013; OECD, 2019; UN, 2023):

- **Economical strategies:** Enhancing productivity in primary sectors; creating new employment opportunities; developing credit, insurance, and financial support mechanisms; promoting income growth and reducing poverty and inequality; supporting multisectoral rural development; encouraging entrepreneurship, vocational training, and competitiveness in rural economies; advancing the knowledge economy; fostering innovation and technology adaptation; promoting renewable energy and sustainable production-consumption patterns; strengthening rural value chains.
- **Technical strategies:** Increasing accessibility to basic services; improving transportation and mobility systems; upgrading rural infrastructure; developing e-services and improving digital literacy; integrating new technologies into daily life and production; enhancing access to sustainable and clean energy sources.
- **Social strategies:** Enhancing accessibility and quality of social services; improving the quality of education and promoting lifelong learning; ensuring equality, equity, and social inclusion; addressing the needs

of disadvantaged groups; reducing interregional disparities; fostering participation and new social networks; promoting rural cultural heritage and community resilience; supporting cooperatives and community-based organizations.

- **Environmental strategies:** Ensuring environmental conservation; preserving natural and cultural resources; promoting the sustainable management of natural resources; addressing climate change adaptation and mitigation; supporting land use planning and landscape protection; encouraging biodiversity preservation; promoting responsible production and consumption.
- **Institutional strategies:** Enhancing transparency, accountability, and participatory governance; developing new rural policies and institutional frameworks; strengthening coordination between public, private, and civil society actors; promoting open data and digital governance; supporting decentralized, locally tailored solutions; facilitating partnerships and collaborative networks; improving service flexibility and adaptive policy tools; supporting strong institutions, rule of law, and inclusive governance mechanisms.

These strategies aim to support sustainable rural development, reduce migration, retain youth, and improve rural welfare. Recent policies also increasingly address global challenges like climate change, warming, and food security.

While these strategies provide a valuable framework for understanding the multidimensional aspects of rural quality of life, their practical relevance can be better understood through concrete examples. In order to do so, implementations from various European countries under the LEADER program, which is widely recognized as a key instrument for supporting rural development in the EU, are briefly presented. These cases illustrate how theoretical strategies are put into practice at the local level and demonstrate tangible steps taken to improve rural quality of life. The common characteristic of these examples, as highlighted in this section, is that none explicitly target “rural quality of life” as a goal; however, all the issues addressed in their proposed solutions closely align with the dimensions of rural quality of life. Thus, this section demonstrates the direct relationship between rural policies and rural quality of life.

Economical strategies – Cultivation Academy in Sweden

The *Odlingsakademien* project in Sweden aimed to strengthen agricultural production in order to create more sustainable and resilient rural settlements. To achieve this, the initiative focused on increasing the community’s knowledge and skills related to sustainable farming practices, while emphasizing the promotion of local production. It actively involved diverse segments of

the population in training programs designed to enhance production capabilities. Moreover, producers were educated in environmentally friendly farming techniques, and new networks were established to facilitate knowledge exchange, particularly bringing together older and younger farmers. Consequently, the project not only supported economic development but also fostered a strong sense of community and belonging (European Commission, n.d.a). In addition, it enhanced the collective capacity for collaboration and action, creating enabling environments where local actors could work together effectively, thereby contributing to significant improvements in the overall quality of life within these rural communities.

Technical strategies – Broadband 4 Our Community in Ireland

The *Broadband 4 Our Community* project in Ireland aimed to increase connectivity through investments in internet infrastructure, thereby enhancing digital inclusion. By establishing a local network, the project also managed to reduce infrastructure costs. A social enterprise was created, allowing profits to be shared with the local community. The initiative employed an FTTP (Fiber to the Premises) network and successfully established a model of social and financial innovation, attracting co-funding from local businesses. Improvements in internet infrastructure facilitated opportunities such as remote working (European Commission, n.d.b). Although the primary objective was to develop technological infrastructure, the project also generated positive economic and social impacts, thereby contributing to improvements in the quality of life.

Social strategies – The Most Pessimistic Town in Finland

In Finland, a project was developed to address the challenges faced by rural settlements experiencing both population decline and aging. Referred to as “the most pessimistic town in Finland,” the community suffered from reduced services and recreational opportunities. The initiative aimed to foster a happier social environment and improve living standards. Beyond social infrastructure, the project incorporated approaches related to tourism, the establishment of new businesses, and the promotion of local culture. Its goal was to transform a pessimistic community into an optimistic one, primarily by engaging young people through humorous and creative activities. Existing pessimism was rebranded as a source of entertainment and cultural identity, encouraging participation in cultural events. The project had a positive impact on local economic development and stimulated cultural regeneration. It also strengthened the community’s sense of belonging and expanded social services and employment opportunities for the youth (European Commission, n.d.c). Thus, while rooted in social infrastructure, the project effectively addressed multiple dimensions of rural quality of life.

Environmental strategies – Na-Tür-lich Dorf, Germany

The *Na-Tür-lich Dorf* project in Germany primarily aimed to prevent environmental degradation and promote environmental conservation. Alongside these environmental priorities, the project also focused on empowering local communities and supporting entrepreneurship. New economic opportunities based on natural resources were created, and various training programs were provided for nature-friendly production methods. The initiative fostered social awareness regarding environmental issues and included the renovation of buildings following ecological architecture principles. Implemented through the collaboration of diverse stakeholders from both local communities and various levels of government, the project contributed to the sustainable development of rural areas. Moreover, it was recognized at both regional and national levels, highlighting its broad impact and significance (European Commission, n.d.d). Although the main emphasis was on environmental protection, the project adopted a holistic approach by addressing multiple dimensions of quality of life to improve rural inhabitants' living conditions.

Institutional strategies – Giovani Dentro, Italy

The *Giovani Dentro* project in Italy aimed to assess the quality of life of young people and identify challenges in order to develop targeted policies. Initiated as a research project in Italian rural mountain areas, it sought to promote sustainable local development by fostering new networks among stakeholders and encouraging participation. The project led to the development of new policies focused on education and improving knowledge related to livestock farming, accompanied by a pilot implementation (European Commission, n.d.e). While primarily addressing governance issues, the initiative also encompassed economic, social, and technical infrastructure dimensions. By doing so, it contributed to enhancing various aspects of rural quality of life and supporting the well-being of young residents.

Since the LEADER program is designed to fund and support projects based on local needs, the examples presented here address highly specific and place-based issues. Nevertheless, a broader look at these initiatives reveals that the goals and outcomes they pursue are closely linked to various dimensions of rural quality of life. Although these are individual cases, they reflect a wider trend that is not limited to LEADER alone but can also be observed in the practices of other international frameworks. Within the scope of this study, such illustrative cases were included alongside policy discussions to provide a more grounded understanding of how strategies are implemented in practice.

As observed, rural policies are closely tied to multiple dimensions of quality of life, influencing them directly and indirectly. Although economic factors are among the most significant determinants of quality of life, numerous

non-economic factors also play a crucial role. Challenges include population decline due to migration, climate change impacts, urban sprawl threatening rural identity, and the loss of traditional customs and social practices.

Improving rural quality of life is essential for residents' well-being and the sustainability of rural areas. Therefore, policies and approaches must address both current and anticipated challenges by focusing on economic development and providing social and technical infrastructure and services, through a comprehensive understanding of the multidimensional factors influencing quality of life.

International rural policies and practice examples were utilized in this study primarily as a theoretical basis to explore the link between quality of life and policy frameworks, due to their global relevance. However, drawing specific lessons from these policies for Türkiye or evaluating the feasibility of their implementation falls beyond the scope of this study and remains a subject for future research. The objective of this study is to establish the theoretical underpinnings, with the next section analyzing how rural policies during the Planned Period in Türkiye align with the dimensions of rural quality of life.

POLICIES AND APPROACHES DEVELOPED FOR RURAL SETTLEMENTS IN TÜRKİYE: PAST TO PRESENT

The rural population in Türkiye began to decline in the 1950s, and the urban population surpassed it for the first time in 1985. Since then, the rural population has undergone a steady decrease (Figure 2). A substantial decline was observed following the enactment of Law No. 6360 in 2012, which reclassified villages within metropolitan municipality boundaries as neighborhoods. This change led to a statistical reduction in the rural population, although it did not reflect an actual demographic shift. According to the provisions of this legislation, approximately 7% of the total population was considered rural in 2021 (TÜİK, 2021). However, under TÜİK's updated urban-rural classification system, this figure was reported to be 17.3% in 2022 (TÜİK, 2023).

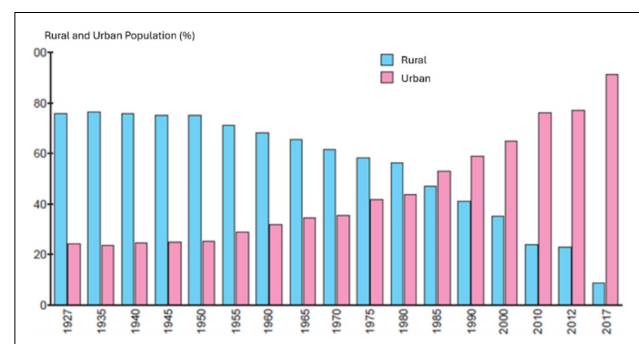


Figure 2. Changing rural and urban population rates in Türkiye between 1927-2017 (TÜİK, 2017).

Since the establishment of the Republic, various policies and approaches have been implemented for rural settlements in Türkiye. These efforts aimed to promote rural development, sustainability, and stability, and were shaped by shifting political, economic, and international dynamics. In this context, the evolution of rural policy in Türkiye can be divided into three main periods based on significant turning points:

1. **The Early Republican Period (1923–1946)**, during which policies and approaches toward rural settlements were shaped by the goals of post-war recovery and modernization;
2. **The Pre-Planned Period (1946–1963)**, which began with the transition to multi-party democracy and was marked by the introduction of new economic perspectives, representing a transitional phase; and
3. **The Planned Period (1963–...)**, characterized by the introduction and implementation of National Development Plans.

This study focuses specifically on the Planned Period (1963–...), which itself can be subdivided into two distinct phases based on critical milestones:

- The first period is between **1963–1980**, when policies and approaches were predominantly shaped and implemented by the state; and
- The second period is **post-1980**, marked by the growing influence of neoliberalism, globalization, and the information age.

The earlier periods are summarized below in order to provide context for understanding the state of rural settlements at the outset of the Planned Period (Figure 3).

The Early Republican Period (1923–1946)

This period marked the foundation of a new nation and the launch of post-war recovery and modernization efforts. These efforts had a significant influence on rural settlement strategies. During this period, the focus was mainly on economic and spatial characteristics, as well as social development. Additionally, improvements were made in cultural and physical conditions and service provision. These multidimensional efforts reflect an early holistic approach to rural policy-making that considered various

facets of rural life, even if it was not explicitly framed as such at the time.

Rural policies during this period prioritized the improvement of economic conditions for those engaged in agriculture, primarily through targeted legislation and regulatory measures. Within the context of a statist, protectionist, and inward-oriented economy, rural and agricultural policies were closely aligned with national strategies. From a spatial perspective, the Village Law, which continues to exert influence over certain rural settlements today, played a crucial role in shaping rural policy. This period was characterized by initiatives aimed at the systematic planning and establishment of new villages from the ground up. In terms of social development, significant emphasis was placed on educating the rural population, leading to notable advancements in this domain. Although these initiatives improved rural welfare and agricultural productivity, limited post-war resources and adverse global economic conditions prevented the full realization of the intended goals.

When evaluated in terms of the dimensions that constitute rural quality of life and their impacts, it can be argued that, despite limited resources, the policies and approaches developed during this period included strategies or practices corresponding to each of these dimensions, many of which were relatively fulfilled in practice.

The Pre-Planned Period (1946–1963)

This period commenced with the advent of the multi-party era and introduced new economic approaches, representing a transitional phase. During this period, most of the previously initiated rural settlement practices were either discontinued or left incomplete, resulting in a relative halt in the development of new rural policies and approaches.

With regard to economic policies targeting rural settlements, agricultural subsidies occupied a central role. These policies were designed to stimulate the agricultural sector through the provision of loans from foreign sources, thereby laying the foundations for reliance on external capital. However, an increase in agricultural mechanization, coupled with a decline in labor demand and inadequate rural service development, triggered a rapid migration process to urban areas.

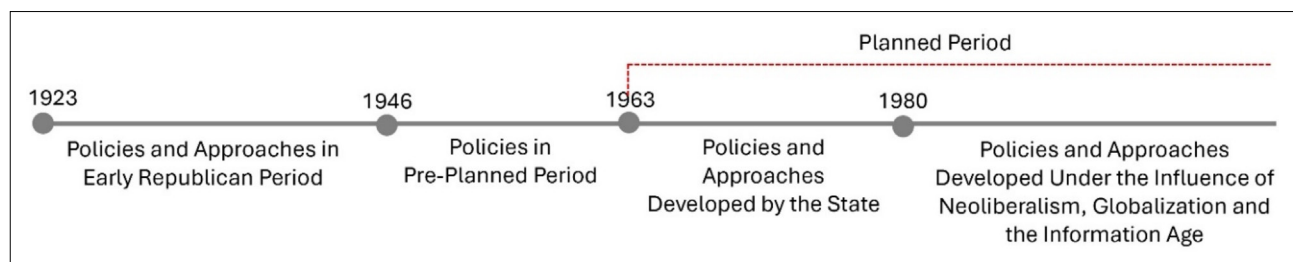


Figure 3. Milestones of policies and approaches developed for rural settlements in Türkiye by periods.

When evaluated through the framework of rural quality of life dimensions, this period appears to have focused mainly on economic concerns, particularly through the implementation of policies designed to attract foreign capital. As a result, it is difficult to assert that significant progress was made in enhancing the overall quality of life in rural settlements during this time. This phenomenon also sheds light on the substantial rural population decline that was observed towards the end of the period. At the same time, new and significant advancements occurred in urban areas. Emerging employment opportunities, improved services, and better living conditions began to raise the quality of life in cities relative to rural regions. Therefore, from a quality of life perspective, this demographic shift is closely linked to the growing appeal and improving conditions of urban life during this period.

Within this context, the dynamics of rural settlements and global developments during these two periods led to new approaches in the Planned Period.

Rural Settlement Policies and Approaches in the Planned Period (1963–...)

As discussed in the section on quality of life in rural settlements, the 1960s marked a significant turning point globally, where the concept became more relevant in development discourse. This period also witnessed the initiation of national planning in Türkiye, introducing long-term strategies for the first time. Although major policy shifts occurred after the 1980s, driven by global influences, the Planned Period fundamentally shaped the contemporary conditions of rural settlements in Türkiye.

Over twelve Five-Year Development Plans (FYDPs), Türkiye has aimed to improve rural living standards and drive national economic growth. Most of these plans focused on reducing regional disparities, enhancing rural well-being, improving service delivery, and guiding investment in rural areas. However, persistent challenges in implementation led many plans to call for new approaches.

This study divides the Planned Period (1963–...) into two sub-periods due to major shifts. From 1963 to 1980, rural policies were state-driven, while the post-1980 phase was

shaped by neoliberalism, globalization, and the information age. Both periods are analyzed in the following sections through the lens of rural quality of life.

Policies and Approaches Developed by the State (1963–1980): Between 1963 and 1980, policies and approaches toward rural settlements were predominantly developed within the framework of development plans. The institutional responsibilities for implementation were assigned to various organizations in accordance with the administrative structure of the period (Figure 4).

The first distinctive initiative of this period was the **Model Village Approach (1963–1966)**, developed independently of national plans. This approach aimed to improve selected villages as benchmarks for surrounding areas, promoting the diffusion of services. Villages were planned with functional zones such as “cultural” and “agricultural” sites (Kılıç, 1997) (Figure 5). From a quality of life perspective, the implementation primarily concentrated on the **social infrastructure** dimension, neglecting the others. The lack of public participation and failure to address local needs eventually led to the discontinuation of the initiative.

Building upon earlier efforts, the **Community Development Approach** was adopted alongside the **First FYDP (1963–1967)**, emphasizing the need to improve services in rural settlements. Initially developed by the United Nations (UN), this approach aimed to foster collaboration between state

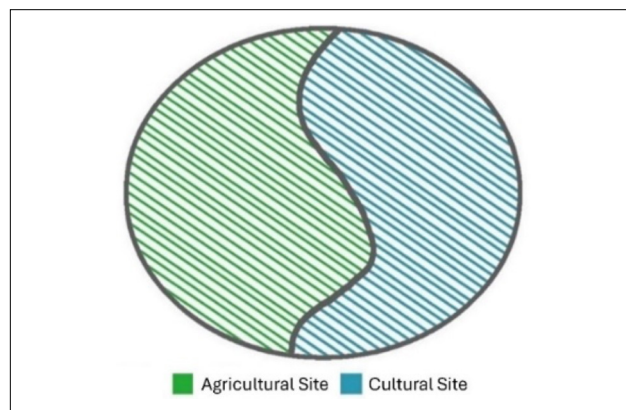


Figure 5. Model village.

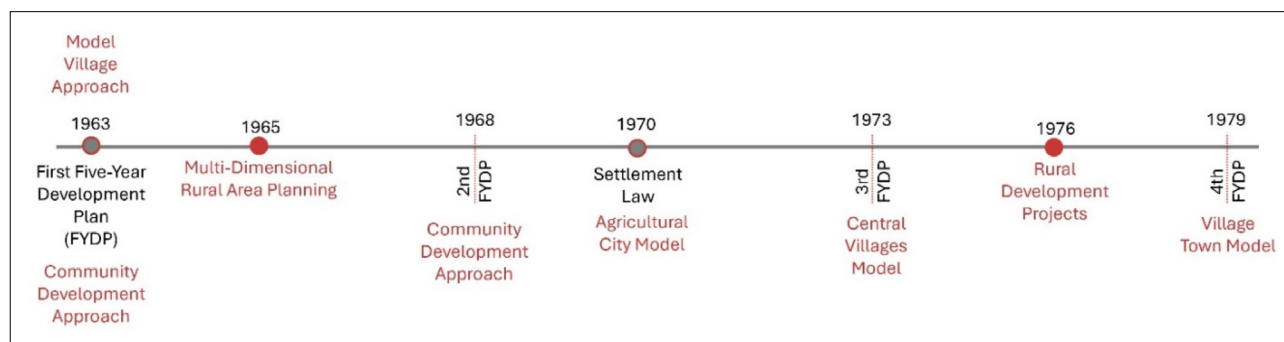


Figure 4. Timeline of rural settlements policies developed by the state between 1963-1980.

institutions and rural communities in service provision. Key elements included the establishment of agricultural cooperatives, expansion of agricultural training programs, creation of new employment opportunities, reduction of regional social disparities, enhancement of rural productivity, and optimization of service delivery (DPT, 1963). The **Second FYDP (1968–1972)** further highlighted the importance of addressing rural and urban issues jointly. It encouraged dialogue between local residents and public officials to identify needs and develop tailored solutions (DPT, 1968). The responsibilities of villagers were generally framed as voluntary participation in public activities, fostering cooperation, and constructing housing with loans and standardized designs (DPT, 1968). Implemented in various provinces, this approach addressed all dimensions of quality of life **except the environmental one**. However, institutional goals fell short due to weak legal and administrative frameworks and frequent institutional changes, limiting public participation (Kılıç, 1997; Çelik, 2005).

As an alternative, in 1965 the **Multi-Dimensional Rural Area Planning** approach was developed, aiming to increase the self-sufficiency, livability, and attractiveness of rural settlements while promoting the rational use of resources. This approach included components such as family planning, social services, agricultural production development, marketing, cooperatives and credits, transportation and infrastructure development, spatial planning, and environmental protection, with the objective of eliminating rural–urban inequalities (Geray, 1974; Kılıç, 1997; Çelik, 2005). Drawing from international practices, the model underscored the necessity of a holistic approach. It advocated for planning at macro, micro, and regional levels, supported by integrated development parameters. The approach also proposed standardized designs for similar types of settlements.

Due to financial and technical constraints, the approach was restructured in 1966 into two stages: **village planning** and **village cluster planning** (Kılıç, 1997). Consequently, the concept of village clusters was incorporated into Türkiye's rural settlement policy for the first time. Between 1965 and 1975, this approach was implemented in several provinces. However, due to lack of coordination among administrative units and insufficient technical personnel, the approach remained limited to district-based projects and failed to integrate with regional plans (Çelik, 2005). From a quality of life perspective, this approach addressed all dimensions **except the institutional one**. Consequently, the absence of public participation contributed to the discontinuation of these projects.

The **1970 Settlement Law** aimed to resolve rural settlement issues through spatial solutions, such as relocating unsuitable villages, consolidating scattered ones, and providing housing and infrastructure support. From a quality of life perspective, it focused mainly on **technical and environmental** aspects, neglecting **economic, social, and institutional** dimensions. As Doğanay (2002) notes,

limited budgets and technical staff hindered widespread implementation.

The **Third FYDP (1973–1977)** emphasized the integrated organization of agricultural, technical, and social services. In this context, the **Central Village Approach** was introduced to extend these services to surrounding rural areas through central villages selected based on specific criteria (Figure 6; DPT, 1973). These villages were planned to host key facilities such as schools, health centers, vocational training units, agricultural extension services, and marketplaces.

Continued under the **Fourth FYDP (1979–1983)**, the central village approach aimed to create service hubs for trade, education, and health (DPT, 1979). While it addressed **economic and social infrastructure**, it neglected other dimensions of quality of life. As Geray (1974) and Kayıkçı (2005) note, the initiative focused on services but failed to address deeper socio-economic issues or introduce innovative economic strategies.

Rural Development Projects, initiated in the 1970s and predominantly funded by foreign sources, aimed to reduce rural-to-urban migration by improving resource use, infrastructure, and socio-economic conditions (Çelik, 2005). The pursuit of foreign capital during this period signaled the subsequent phase, gradually paving the way for increased dependence on international financial sources and alignment with global policy frameworks. Between 1976 and 2010, efforts focused on modernizing agriculture, infrastructure, farmer education, and living standards (Doğanay, 1993; Çelik, 2005). While these projects addressed all quality of life dimensions **except the institutional one**, most indicators were vague.

The **Fourth FYDP (1979–1983)** introduced measures to address income imbalances between rural and urban regions, promote agricultural development, and facilitate the transition to an industrial society. These goals were to be achieved through land reform policies, support for cooperative enterprises, and the introduction of the **Village Town model** (DPT, 1979). The approach sought to advance existing villages by promoting specialization in specific economic domains and prioritized collaboration among neighboring villages (Figure 7).

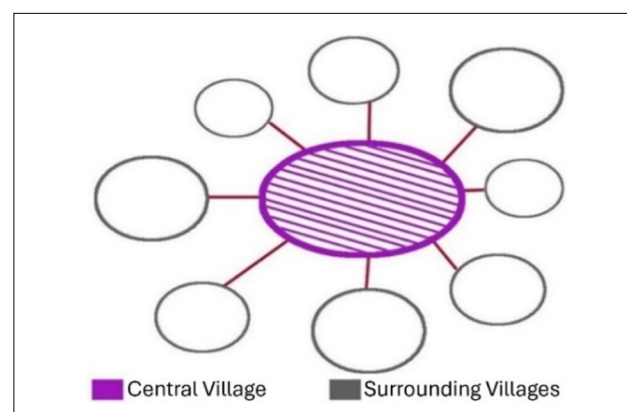


Figure 6. Central village approach.

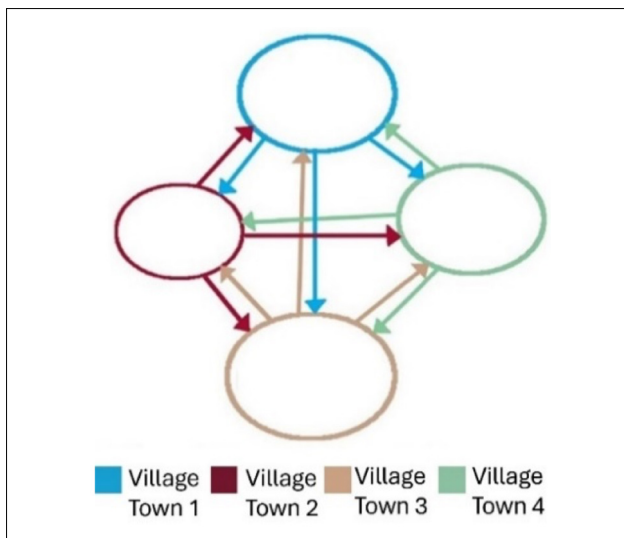


Figure 7. Village Town Model.

This approach aimed to integrate rural and urban areas through spatial planning and service provision (Polat, 2000), with pilot projects focused on infrastructure, social services, and cooperatives. Investments included transportation, water, sanitation, education, healthcare, and economic activities like agriculture, forestry, and tourism (Başbüyük, 2004). Although it addressed all quality of life dimensions **except the institutional one**, many indicators lacked clarity. Limited to a few villages, the projects failed to achieve rural-urban integration and were often halted due to low participation or administrative changes.

In summary, institutional dimension was largely neglected in rural policies of this period. While economic, technical, social, and environmental goals existed, indicators and implementation were often vague. Failures were mainly due to limited public participation, insufficient funding, and unmet local needs. The dimensions and indicators associated with this period are presented in a table and further discussed in the discussion and conclusion section.

Policies and Approaches Developed Under the Influence of Neoliberalism, Globalization, and the Information Age (1980–...):

Neoliberal policies that began to influence Türkiye in the post-1980 period reduced the state's economic involvement, cut public employment, and withdrew agricultural support (Gürçam & Aydın, 2019). As Soyak (2003) notes, the Five-Year Development Plans (FYDPs) became largely advisory during this period. From this point onward, international institutions such as the IMF, WB, WTO, OECD, and the EU began to exert a dominant influence over Türkiye's economic agenda, reshaping rural development policies to align with their priorities—especially the EU's Cohesion Policy (Figure 8).

New economic policies caused rural incomes to decline, which in turn reduced quality of life and accelerated migration from rural to urban areas. Although international organizations promoted sustainable rural development and quality of life, implementation in Türkiye's rural areas was limited. Despite the continuation of the FYDPs, the influence of local governments weakened, and state involvement in rural spatial planning declined. As a result, neoliberal policies affected not only the economy but also various dimensions of quality of life in rural settlements.

The **Fifth FYDP (1984–1989)** aimed to retain villagers in rural areas by enhancing quality of life, continuing the Central Village model with an emphasis on economic development and **social infrastructure** (DPT, 1984). Meanwhile, economically challenged urban residents and retirees began relocating to rural settlements, indirectly increasing demand for amenities in these areas. The **Sixth FYDP (1990–1994)** promoted agricultural industrial investments in Central Villages and sought to align regional policies with the EU (DPT, 1990). In 1995, the WTO Agriculture Agreement shifted agricultural production and trade toward market mechanisms, weakening state support (Şahinöz, 2010). Following this, Türkiye began harmonizing its policies with the EU Customs Union and the Common Agricultural Policy, eventually achieving EU candidate status in 1999.

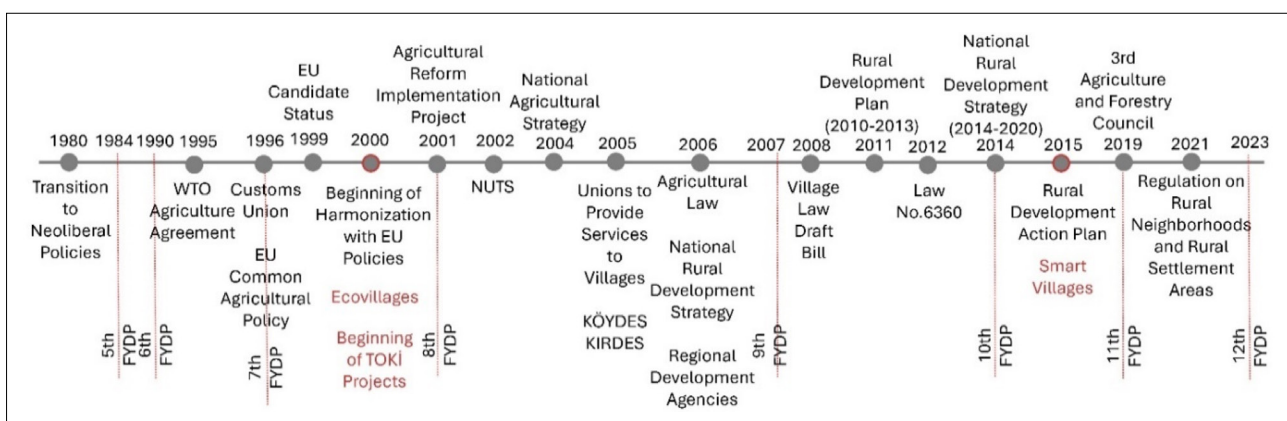


Figure 8. Timeline of policies in the planned period of post-1980s.

The **Seventh FYDP (1996–2000)** introduced the concept of "sustainable development" with the objective of ensuring agricultural development compatible with environmental protection. Both the Seventh and **Eighth FYDPs (2001–2005)** highlighted that the absence of land use plans for rural settlements led to the non-agricultural use of agricultural lands, negatively impacting agricultural productivity. In response, they proposed the implementation of preventive legal regulations and the preparation of zoning plans. These two plans marked an important step in explicitly recognizing indicators related to the **environmental** dimension of quality of life, while considering its interrelation with the **economic** dimension.

Furthermore, the plans suggested aiding entrepreneurs to foster rural industry (DPT, 2000). Due to harmonization with EU policies, the initiation of the **Agricultural Reform Implementation Project** in 2001 emphasized support for farmers and cooperatives (Eştürk & Ören, 2014). In 2002, in order to benefit from financial aid programs, **Rural Development Agencies** and **Regional Development Agencies** were established according to the Nomenclature of Territorial Units for Statistics (NUTS). Although these agencies originally had distinct responsibilities and operational fields, as Akin and Yıldız (2005) point out, they were later consolidated, which resulted in challenges related to administration and implementation. Consequently, Regional Development Agencies were transferred to the Ministry of Industry and Technology, and the Rural Development Agencies were dissolved. As a result, Regional Development Agencies assumed responsibility for rural development policies, but their role generally remained limited to financial support for related initiatives.

In 2004, a **National Agricultural Strategy** was adopted for the first time, outlining several key priorities (Çelik, 2005): improvement of rural infrastructure; renewal of villages; regulation of agricultural lands and prevention of their misuse; protection and management of natural resources; support for producer organizations; investment in both agricultural and non-agricultural sectors; promotion of agricultural-industrial integration; development of organizations for the marketing of new production methods and products; mitigation of damage caused by natural disasters; and vocational training for rural communities. In line with these objectives, the **Agricultural Law** was enacted in 2006 to advance rural regions and support the agricultural sector. In the same year, the **National Rural Development Strategy** was introduced as a comprehensive policy framework to address the challenges faced by rural communities. The preparation of these documents specifically targeting rural settlements marked a positive step aligned with international efforts to improve quality of life in rural areas. However, due to the lack of effective implementation mechanisms, the quality of life in rural settlements—particularly the economic dimension—has

continued to deteriorate. Moreover, the persistent gap in opportunities compared to urban living standards has further accelerated rural-to-urban migration.

The **Ninth FYDP (2007–2013)**, aligned with EU accession, prioritized organic farming, e-commerce, support for young and women farmers, and food security. It highlighted sustainable resource use, water basin planning, and building a competitive agricultural sector, with district and town municipalities playing a key role in facilitating rural development (DPT, 2007b). This indicated a hint of the continuation of the Central Village approach—with a slight shift toward emphasizing the economic dimension of quality of life—and with priority given to tourism, conservation, and high-risk disaster areas.

In 2007, the **Agriculture and Rural Development Support Institution** was established for channeling grants, such as from the **Rural Development Investment Support Program** and **IPARD**, provided by the EU to farmers' investments. In this context, several indicators related to the **economic** dimension of quality of life in rural settlements were also brought to the agenda. Furthermore, with the adoption of the EU's **LEADER** program, efforts have been made to involve local stakeholders in decision-making processes and to improve rural living conditions, thereby addressing the **institutional** dimension of quality of life in rural settlements. However, although these economy-oriented programs developed under EU frameworks originally included spatial strategies, their adoption in Türkiye has largely lacked such components, raising concerns about their effectiveness in enhancing rural living.

The **General Directorate of Rural Services** was abolished, with its duties transferred to the Ministry of Public Works, while village responsibilities shifted to metropolitan municipalities and special provincial administrations. **Law No. 6360 (2012)** reclassified villages as neighborhoods within metropolitan areas, leading to economic challenges due to urban-level service charges and additional municipal obligations. This change affected all dimensions of quality of life, especially the **institutional** aspect, resulting in uncertainty in service provision. To address this, the **KÖYDES** and **KIRDES** projects were launched to support local and metropolitan rural municipalities.

The **Tenth FYDP (2014–2018)** introduced renewable energy for the first time, focusing on installing technology-based infrastructure to create an efficient and competitive agricultural sector. The plan also underscored the significance of social services and widespread internet use in enabling elderly and disabled participation in socio-economic activities (T.C. Kalkınma Bakanlığı, 2014). Additionally, the necessity for a revised definition of "rural" was highlighted. In order to guide rural policies, the **Second (2014–2020) and Third National Rural Development**

Strategy (2021–2023) and the Rural Development Action Plan (2015–2018) were adopted by the Ministry of Agriculture. The primary objectives of these documents set forth the promotion of participation and organization, the facilitation of problem-solving, the provision of basic social and infrastructural requirements, the generation of sustainable income sources, the encouragement of entrepreneurship, the implementation of sustainable management of natural resources, and the strengthening of NGOs in the conservation of rural heritage and environment (Kan et al., 2020). Compared to previous FYDPs, these plans and strategies address multiple dimensions of quality of life in rural settlements more comprehensively, reflecting international approaches they seek to align with.

The **Eleventh FYDP (2019–2023)** proposed a framework leveraging innovative and environmentally friendly methods, digital opportunities, artificial intelligence, and data in the realm of smart agricultural technologies. It outlined the expansion of measures addressing climate change, sustainable agriculture, training for Good Agricultural Practices, contracted farming, clustering, research, marketing, and branding activities. Additionally, the plan envisaged the sustainability of the rural population, as well as the preservation of heritage, natural and cultural assets. It also emphasized the promotion of authentic handicrafts, agrotourism, the cultivation of alternative agricultural products, and the transfer of traditional production methods to future generations (T.C. Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2019). While primarily focusing on the **economic and environmental** dimensions of quality of life in rural settlements, the **Final Declaration of the Third Agriculture and Forestry Council**, held the same year, placed greater emphasis on the institutional dimension by outlining the restructuring of neighborhoods affiliated with metropolitan municipalities under Law No. 6360. Accordingly, the **2021 Regulation on Rural Neighborhoods and Rural Settlement Areas** classified settlements within metropolitan municipality boundaries that were converted into neighborhoods as “rural neighborhoods.” To this end, metropolitan municipalities were tasked with assessing neighborhoods exhibiting rural characteristics (T.C. Resmi Gazete, 2021). Consequently, the introduction of the terms “rural neighborhood” and “rural settlement” has aimed to facilitate a rethinking of rural areas. However, unclear procedures and the lack of defined status for these settlements within the planning hierarchy raise questions regarding differentiation among rural settlements. In this context, it is crucial to clarify which settlements will be encompassed by national rural settlement policies and how the distribution of administrative responsibilities will be determined.

The **Twelfth FYDP (2024–2028)** proposed the advancement of social prospects for women and youth in rural communities

with equal opportunities. Furthermore, the plan includes targets such as the development of innovative projects designed to facilitate reverse migration to rural settlements, the enhancement of quality of life, and the revitalization of the socio-economy based on the characteristics and potentials of the local area. While the plan emphasizes improving quality of life in rural settlements, it does not comprehensively cover all relevant dimensions and their interconnections.

Since the 1980s, FYDPs have introduced no new approaches for rural settlements. From the 2000s onward, state efforts have focused on **Agricultural Villages** built through TOKİ in post-disaster rural settlements. These projects aim to reduce migration by improving livelihoods, production, and social life (TOKİ, n.d.). However, Açmaz Özden & Özden (2019) criticize them for focusing mainly on replicated housing without public facilities, neglecting local authenticity, environment, and quality of life (Figure 9). In other words, these rural construction projects lack an agenda for providing a quality of life for their residents.

Apart from projects initiated by TOKİ and governmental ministries, most rural settlement initiatives such as **ecovillages and smart villages** are predominantly driven by private investors motivated mainly by economic objectives. While these projects may inadvertently foster urban-to-rural migration, they often fall short of adequately addressing the specific needs and challenges of existing rural communities. Moreover, rather than enhancing quality of life, these projects—especially when located in or adjacent to existing rural settlements—tend to disrupt the balance of the rural living environment. For instance, they encroach upon or degrade the nearby natural environment, exploit natural resources used by the local population, or indirectly alter the local economic structure due to the socio-economic characteristics of newcomers. These impacts, in turn, negatively affect the quality of life for long-standing residents, particularly in its **economic, environmental, and social** dimensions. Furthermore, the independent evolution of these initiatives is largely attributable to the absence of comprehensive, coordinated policies and strategic frameworks at the national level, which hampers their potential to contribute effectively to sustainable rural development.

To summarize the rural policies of this period, although most of them mainly focused on the economic dimension, it is evident that each policy emphasized different aspects of quality of life rather than considering it as a holistic concept. The main shortcomings of these strategies were the lack of clearly defined tools and the absence of a well-structured and planned institutional framework. The dimensions and indicators associated with this period will be presented in a table and discussed in more detail in the discussion and conclusion section.



Figure 9. Agricultural village samples (TOKİ, n.d.).

DISCUSSION AND CONCLUSION

A review of the literature and documentary evidence in this research indicated that the policies and approaches to rural settlements in Türkiye have been short-term, whereas the majority of them sought to address similar problems and proposals from a piecemeal perspective, either incomplete or not implemented.

Between 1963 and 1980, most policies introduced new rural settlement approaches. After 1980, while some strategies persisted—mainly with the Central Village model—no fundamentally new approaches were adopted (Table 4; Table 5; Table 6).

In the first sub-period, rural approaches addressed various quality of life dimensions, except the institutional one. Although each dimension included indicators, clear implementation plans were largely missing. Economic goals like improving agriculture and specialization lacked defined tools. Technical and social infrastructure were mentioned as broad improvements without concrete strategies. Nevertheless, the environmental dimension had fewer indicators, acknowledging goals like protection and efficiency but without clear methods to achieve them. The sustainability of the approaches was limited by weak authority delegation, staff shortages, limited funding, and low public participation.

In contrast, the post-1980 period shifted focus towards **economic and environmental** dimensions. During this period, economic indicators became more detailed,

outlining key sectors for rural investment. This increased specificity, particularly in these two areas, reflects Türkiye's shift toward international frameworks and the EU accession process. As rural policies began to align with the priorities and standards of the EU and other global actors, the emphasis transitioned from merely identifying goals to partially defining actionable pathways for achieving them. Institutional indicators like public participation and legal regulations were added to policies, also largely drawn from international sources rather than local needs or inputs from the community. The financial sources were unclear, public communication methods were unspecified, and rural priorities were poorly defined. Although technical and social infrastructure indicators remained in policies, they continuously lacked clear tools or implementation strategies, which highlighted a major gap in addressing quality of life comprehensively.

Beyond the rural settlement policies addressed and reflected in the tables within this study, there are, of course, other policies as well as sectoral ones. The policies and approaches evaluated in this study have been limited in scope to those that represent the most significant historical turning points and have shaped the overall trajectory. Furthermore, repeated indicators from previous periods were not duplicated in the tables due to the lack of new discourse. The recurring issues and recommendations highlight a failure to incorporate lessons from the past. Despite frequent mentions of participation in FYDPs, policies often overlooked local needs and priorities. Theoretical solutions were

Table 4. Comparison of rural settlement policies between 1963 and 1980 based on the dimensions of quality of life in rural settlements

Governmental Policy	Approach	Dimensions and Indicators of Quality of Life			
		Economic	Technical Infrastructure	Social Infrastructure	Environmental Institutional
-	Model Village (1963-1966)	-	-	Improvement of services Creation of new public buildings	-
First Five-Year Development Plan (1963–1967)	Community Development	Agricultural cooperatives Agricultural extension New employment opportunities	Housing construction	Improvement of services Reduction of regional social disparities	Collaboration between state institutions and rural communities
Second Five-Year Development Plan (1968–1972)		Training programs			Participation
-	Multi-Dimensional Rural Area Planning (1965-1975)	Agricultural production development Marketing Cooperatives Credits	Transportation and infrastructure development	Family planning Education Health Social services	Rational use of resources Spatial planning Environmental protection
Settlement Law (1970)	-	Credits	Relocating villages to more accessible locations for infrastructure Standardized building plans	-	Standardized village layout
Third Five-Year Development Plan (1973–1977)	Central Village Approach	Vocational training Agricultural extension Marketplaces Trade hubs	-	Extending services Service hubs	-
-	Rural Development Projects (1976-2010)	Economic development Modernizing primary sectors Educating farmers Providing credits	Infrastructural development	Social development	Efficiency of natural resource utilization
Fourth Five-Year Development Plan (1979–1983)	Village Town (1979-2001)	Specialization in economic fields Cooperatives and credits Production facilities Crop production Tourism	Infrastructure Transportation	Service provision at urban standards Social services Education Healthcare Sports, playgrounds and religious facilities Community centers	Spatial planning

Table 5. Comparison of rural settlement policies after 1980 based on the dimensions of quality of life in rural settlements

Governmental Policy	Approach	Dimensions and Indicators of Quality of Life				
		Economic	Technical Infrastructure	Social Infrastructure	Environmental	Institutional
Fifth Five-Year Development Plan (1984–1989)	Central Village Approach (Continuation)	Continuation	-	Continuation	-	-
Sixth Five-Year Development Plan (1990–1994)	Central Village Approach (Continuation)	Agricultural industrial investments	-	Service provision on health and education	-	-
Seventh Five-Year Development Plan (1996–2000)	-	Agricultural development	-	-	Environmental protection. Land use and zoning plans	Legal regulations-
Eighth Five-Year Development Plan (2001–2005)	-	-	-	-	Land use and zoning plans	Legal regulations
National Agricultural Strategy (2004)	-	Support for producer organizations Investment in agricultural and non-agricultural sectors	Infrastructure	-	Renewal of villages Protection and management of natural resources	Legal regulations
Agricultural Law (2006)		Agricultural-industrial integration			Mitigation of damage caused by natural disasters	
National Rural Development Strategy (2006)		New production methods and products				
		Vocational training				
Ninth Five-Year Development Plan (2007–2013)	-	Organic farming e-commerce Support for young and women farmers Competitive agricultural sector	-	-	Sustainable utilization of natural resources Planning of water basins	-
Tenth Five-Year Development Plan (2014–2018)	-	Efficient and competitive agricultural sector	Installation of technology-based infrastructure Use of the internet	Social services	Renewable energy	-
Second National Rural Development Strategy (2014–2020)	-	Sustainable income sources Encouragement of entrepreneurship	Provision of basic infrastructural requirements	Provision of basic social requirements	Sustainable management of natural resources Conservation of rural heritage and environment	Participation and organization Facilitation of problem-solving
Third National Rural Development Strategy (2021–2023) (T.C. Tarım ve Orman Bakanlığı, 2021)						
Rural Development Action Plan (2015–2018)						

Table 6. Comparison of rural settlement policies after 1980 based on the dimensions of quality of life in rural settlements (continued from Table 5)

Governmental Policy	Approach	Dimensions and Indicators of Quality of Life				
		Economic	Technical Infrastructure	Social Infrastructure	Environmental	Institutional
Eleventh Five-Year Development Plan (2019–2023)	-	Smart agriculture Training for Good Agricultural Practices Contracted farming Clustering Research Marketing and branding activities Promotion of authentic handicrafts Agrotourism Cultivation of alternative agricultural products Transfer of traditional production methods	Digital opportunities Artificial intelligence Use of data	-	Innovative and environmentally friendly methods Climate change Sustainable agriculture Preservation of heritage, natural and cultural assets	-
	-	-	-	-	-	Restructuring of neighborhoods affiliated with metropolitan municipalities
Regulation on Rural Neighborhoods and Rural Settlement Areas (2021)	-	-	-	-	-	-
Twelfth Five-Year Development Plan (2024–2028)				Advancement of social prospects for women and youth		

undermined by poor implementation, limited adaptation to local contexts, and the sidelining of local administrations.

A key challenge has been the dispersed, small-scale nature of rural settlements, making service delivery difficult and costly. However, responses have lacked a holistic view that balances rural–urban dynamics. As a result, rural-to-urban migration has persisted, highlighting the need to boost both the rural economy and quality of life. From a broader perspective, the migration parameters identified in the literature—economic conditions, infrastructure, security, environment, and social structure—closely align with the key dimensions of quality of life in rural settlements. Consequently, it is conceivable that the decline in Türkiye’s rural population and primary economic activities could threaten national food security and the economy, signifying the importance of rural settlement policies for social welfare.

Despite the recognition of these challenges and emerging priorities in national development plans, practical implementation in rural settlement policies remains insufficient. While the recent development plans emphasize new concepts like sustainability, smart technologies, and food security, these are not reflected in rural settlement practices. This gap stems from the absence of a dedicated authority to develop innovative rural approaches. The Ministry of Agriculture and Regional Development Agencies are primarily concerned with the provision of financial assistance to rural communities. However, there is a lack of dedicated institutional capacity for the development of innovative solutions that address the multifaceted challenges facing rural settlements. Given the country’s geographic, climatic, and socio-economic diversity, each rural area has unique needs, which complicates uniform policy implementation and outcomes. As a result, rural development is limited to TOKİ-built housing, which is sold rather than tailored to the needs of economically disadvantaged villagers.

Even more strikingly, since the 1980s, private sector projects in rural areas have mostly focused on building new settlements, often ignoring local identity and socio-economic context. These projects tend to become tourism, real estate, or advertising ventures,

creating communities disconnected from rural culture and economy. In this context, as in pre-1980 efforts and international examples, it's essential for the state—not just the private sector—to lead rural settlement planning and implementation.

Besides evaluating the scope of the policies and approaches regarding the dimensions of rural quality of life, it is equally important to assess their effectiveness in practice. Based on the content analysis presented above, this study also assesses the rural settlement policies and approaches using four **OECD (2021)** criteria: **relevance, coherence, effectiveness, and sustainability**. These criteria provide a qualitative framework not only for evaluating the stated objectives of the policies but also for examining their actual implementation and long-term impacts. This approach allows for a deeper understanding of policy performance, extending beyond the initial scope of analysis. However, due to the lack of detailed quantitative data regarding policy outcomes, this evaluation relies on the presence or absence of clear evidence for each criterion in policy documents and secondary sources.

Although all the policies and approaches reviewed in this study appear to have **relevance** to the identified dimensions of quality of life in rural settlements, their **coherence, effectiveness, and sustainability** vary significantly (Table 7; Table 8).

In the **1963–1980 period**, coherence—examined through the question “*Were the strategies embedded within the policies and approaches coherent and well-aligned with other policies to improve rural quality of life?*”—shows that most of the rural settlement approaches were largely consistent with other national policy goals and development frameworks. However, in the **post-1980 period**, even though rural settlement policies remained conceptually coherent and were included in national development plans, the actual implementation prioritized urban, particularly metropolitan, development. As a result, rural areas were marginalized in practice. Therefore, it is difficult to argue that these rural policies were coherent in terms of their alignment with broader development efforts during implementation.

Regarding **effectiveness**, the question “*When considered in the context of quality of life, have the implementations achieved their objectives?*” reveals that during the 1963–1980 period, many of the proposed approaches were not implemented as originally planned, limiting their ability to meet their stated goals. In the post-1980 period, despite the presence of relevant objectives related to rural quality of life, these policies lacked actionable frameworks or concrete implementation mechanisms. Consequently, strategies built around abstract concepts failed to produce effective outcomes on the ground.

In terms of **sustainability**, the **Central Village approach** is notable for its recurring presence across decades and its implicit continuation in current practices. However, the success of this approach in improving rural quality of life remains open to debate. Other approaches, by contrast, were largely discontinued due to institutional weaknesses, limited funding, and lack of participatory mechanisms. Nevertheless, when looking at laws, plans, and strategic documents—particularly those developed after 1980—some policy elements appear to have conceptual continuity with more recent strategies, likely due to their alignment with global development discourses. Yet this type of sustainability is mostly theoretical and fails to translate into visible improvements in rural quality of life.

Based on these findings and the gaps identified in previous implementations, the following strategic directions are proposed for future rural development policies:

- **Economic strategies** that not only define the targets but also specify the tools to achieve them, such as enhancing production; providing education to support grassroots development; promoting entrepreneurship and expanding employment opportunities through the creation of place-based sectors and products tailored to the capacities of individual settlements; and formulating effective policies that support small-scale enterprises rather than focusing solely on large-scale producers or external investors.
- **Social and technical infrastructure strategies** that extend beyond identifying development needs by addressing the economic instruments necessary for implementation, while also defining the potential roles of communities, cooperatives, and other local actors in this process; as well as developing technological facilities through various public partnerships, integrating them into both production and daily life, and educating the rural population to effectively utilize them.
- **Environmental strategies** that emphasize not only the protection of natural resources and ecosystems, but also clearly define the specific responsibilities of the state and the public in this regard; that encourage the adaptation of successful international conservation practices to local contexts; and that consider both the natural environment and built environment, ensuring that living and production spaces—along with their interrelations—are addressed comprehensively within the broader environmental framework.
- **Institutional strategies** that begin by acknowledging the shortcomings of past approaches, particularly concerning the problematic delegation of authority and limited public participation, and thus emphasize the development of transparent policies and approaches that account for the demographic diversity of

Table 7. Assessment of the effectiveness of rural settlement policies and approaches between 1963 and 1980 on quality of life

Governmental Policy	Approach	Evaluation Criteria			Sustainability
		Relevance	Coherence	Effectiveness	
-	Model Village (1963-1966)	Yes: The approach included interventions regarding social infrastructure	No: The approach was not supported by policies	No: The approach was not implemented as planned	No: The approach was discontinued due to lack of participation and failure to address local needs
First Five-Year Development Plan (1963–1967)	Community Development	Yes: The approach included interventions on all dimensions of quality of life besides environment	Yes: The approach was parallel to the rural policies	Yes: The approach was implemented in various provinces as planned	No: The approach was discontinued due to lack of institutional limits
Second Five-Year Development Plan (1968–1972)					
-	Multi-Dimensional Rural Area Planning (1965-1975)	Yes: The approach included interventions on all dimensions of quality of life besides institution	No: The approach was not applied as originally planned according to the rural policies	No: The approach was implemented in a very limited manner	No: The approach was discontinued due to lack of institutional limits
Settlement Law (1970)	-	Yes: The law included interventions regarding technical infrastructure and environment	Yes: The law was consistent with past and future policies	No: The law was implemented in a very limited manner	Yes: The law remains in Türkiye's rural policies
Third Five-Year Development Plan (1973-1977)	Central Village Approach	Yes: The approach included interventions regarding economy and social infrastructure	Yes: The approach was parallel to the rural policies	No: The approach was implemented in a very limited manner	Yes: The approach was maintained in future policies and practices
-	Rural Development Projects (1976-2010)	Yes: The approach included interventions on all dimensions of quality of life besides institution	Yes: The approach was parallel to the rural policies	Yes: The approach was implemented in various provinces as planned	Yes: The approach is still maintained implicitly
Fourth Five-Year Development Plan (1979–1983)	Village Town (1979-2001)	Yes: The approach included interventions on all dimensions of quality of life besides institution	Yes: The approach was parallel to the rural policies	No: The approach was implemented in a very limited manner	No: The approach was discontinued due to lack of participation or administrative changes

Table 8. Assessment of the effectiveness of rural settlement policies and approaches after 1980 on quality of life

Governmental Policy	Approach	Evaluation Criteria		
		Relevance	Coherence	Effectiveness
Fifth Five-Year Development Plan (1984–1989)	Central Village Approach (Continuation)	Yes: The approach included interventions regarding economy and social infrastructure	Yes: The approach was parallel to the rural policies	No: The approach was implemented in a very limited manner
Sixth Five-Year Development Plan (1990–1994)				Yes: The approach was maintained in future policies and practices
Seventh Five-Year Development Plan (1996–2000)	-	Yes: The plans included interventions regarding economy, environment and institution	No: The plans were not parallel to implementations, especially in urban areas	No: While the plans appear to be holistic, there were no main approaches for implementation
Eighth Five-Year Development Plan (2001–2005)				Yes: The objectives of these plans still remain in today's policies
National Agricultural Strategy (2004)	-	Yes: The strategies and law included interventions on all dimensions of quality of life besides social infrastructure	No: The strategies and the law were not parallel to other national strategies and implementations especially in urban areas	No: While the strategies and the law appear to be holistic, there were no main approaches for implementation
Agricultural Law (2006)				Yes: The objectives of these strategies and law still remain in today's policies
National Rural Development Strategy (2006)				
Ninth Five-Year Development Plan (2007–2013)	-	Yes: The plan included interventions regarding economy and environment	No: The plan was not parallel to implementations, especially in urban areas	No: While the plan appears to be holistic, there were no main approaches for implementation
Tenth Five-Year Development Plan (2014–2018)	-	Yes: The plan included interventions on all dimensions of quality of life besides institution	No: The plan was not parallel to implementations, especially in urban areas	Yes: The objectives of this plan still remain in today's policies
Second National Rural Development Strategy (2014–2020)	-	Yes: The plan included interventions on all dimensions of quality of life	No: The plan was not parallel to implementations, especially in urban areas	No: While the strategies and the plan appear to be holistic, there were no main approaches for implementation
Third National Rural Development Strategy (2021–2023)				Yes: The objectives of these strategies and plan still remain in today's policies
(T.C. Tarım ve Orman Bakanlığı, 2021)				
Rural Development Action Plan (2015–2018)				

Table 8. Assessment of the effectiveness of rural settlement policies and approaches after 1980 on quality of life (Cont.)

Governmental Policy Approach	Evaluation Criteria			
	Relevance	Coherence	Effectiveness	Sustainability
Eleventh Five-Year Development Plan (2019–2023)	Yes: The plan included interventions on all dimensions of quality of life besides social infrastructure and institution	No: The plan was not parallel to implementations, especially in urban areas	No: While the plan appears to be holistic, there were no main approaches for implementation	Yes: The objectives of this plan still remain in today's policies
Final Declaration of the Third Agriculture and Forestry Council (2019)	Yes: The documents included interventions regarding economic, environmental and institutional dimensions of quality of life	No: The documents were not clear regarding their implementation in parallel to other policies and implementations	No: While the documents appear to be holistic, there were no main approaches for implementation	Yes: The objectives of these documents still remain in today's policies
Regulation on Rural Neighborhoods and Rural Settlement Areas (2021)				
Twelfth Five-Year Development Plan (2024–2028)	Yes: The plan included interventions regarding social infrastructure	No: The plan was not parallel to implementations, especially in urban areas	No: While the documents appear to be holistic, there were no main approaches for implementation	Yes: The objectives of these documents still remain in today's policies

different regions. These should enable meaningful local participation in decision-making processes, including educating local communities about the scope and importance of their involvement, while also prioritizing improvements in inter-institutional coordination during implementation—a challenge that has persisted over time.

Overall, rural settlement policies should holistically enhance quality of life, recognizing that rural economies now extend beyond primary sectors. Globalization and the information age have transformed rural areas into multifunctional and multisectoral spaces. Therefore, future strategies must be **multi-dimensional, multi-sectoral, and multi-disciplinary** to reflect these shifts.

To effectively improve the quality of life and prevent rural-to-urban migration, it is essential to identify the **economic, technical, social, environmental, and institutional** dimensions that shape well-being in each community. Place-specific and context-sensitive approaches that address these dimensions comprehensively are crucial for developing sustainable and resilient rural policies. Moreover, as observed in the post-1980 period, it is essential to shift from **abstract goals to concrete implementation objectives** and to address rural settlements in an integrated manner with other sectoral policies and strategies developed for urban areas.

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REFERENCES

- Açmaz Özden, M., & Özden, A. T. (2019). Rethinking the Rural in Solving the Urban Crisis: A Holistic Perspective on the Urban–Rural Relationship [Kentsel krizin çözümünde kırsalın yeniden düşünülmesi: Kent-kır ilişkisine bütüncül bir bakış önerisi. *[City, Construction and Economy Congress] [Kent, İnşaat ve Ekonomi Kongresi] (2–4 Mayıs 2019, Gaziantep)*, 1–16.
- Akın, S., & Yıldız, F. F. (2005). Regional Development Agencies and Their Effects on Turkish Agriculture [Bölgesel kalkınma ajansları ve Türk tarımına etkileri]. *Türk Agriculture Journal of the Ministry of Agriculture and Rural Affairs [Tarım ve Köyişleri Bakan-*

- lığı *Türktarım Dergisi*], 163, 38–44.
- Başbüyük, A. (2004). The Mesudiye (Ordu) Village-Town Project [Mesudiye (Ordu) köy-kent projesi]. *East Geography Review*, 11, 301–26.
- Beslerová, S., & Dzuričková, J. (2014). Quality of life measurements in EU countries. *Procedia Economics and Finance*, 12, 37–47. [https://doi.org/10.1016/S2212-5671\(14\)00318-9](https://doi.org/10.1016/S2212-5671(14)00318-9)
- Brauer, R., & Dymitrow, M. (2014). Quality of life in rural areas: A topic for the rural development policy? *Bulletin of Geography Socio-economic Series*, 25(25), 25–54. <https://doi.org/10.2478/bog-2014-0028>
- Bukenya, J. O., Gebremedhin, T. G., & Schaeffer, P. V. (2003). Analysis of rural quality of life and health: A spatial approach. *Economic Development Quarterly*, 17(3), 280–93. <https://doi.org/10.1177/0891242403255325>
- Çelik, Z. (2005). An evaluation of rural development policies and practices in Türkiye during the planned period [Planlı dönemde Türkiye'deki kırsal kalkınma politika ve uygulamaları üzerine bir değerlendirme]. *Planning Journal [Planlama Dergisi]*, 2005(2), 61–71.
- Dissart, J. C., & Deller, S. C. (2000). Quality of life in the planning literature. *Journal of Planning Literature*, 15(2), 135–61. <https://doi.org/10.1177/08854120022092962>
- Doğanay, F. (1993). *Rural development [Kırsal kalkınma]*. State Planning Organization, General Directorate of Social Planning Publications [Devlet Planlama Teşkilatı Sosyal Planlama Genel Müdürlüğü Planlama Dairesi Başkanlığı Yayınları].
- Doğanay, F. (2002). Rural settlements in Türkiye and the policies developed [Türkiye'de kırsal yerleşmeler ve geliştirilen politikalar]. *Planning Journal [Planlama Dergisi]*, 200(2–3), 90–96.
- Devlet Planlama Teşkilatı (DPT). (1963). *First Five-Year Development Plan [Birinci Beş Yıllık Kalkınma Planı] (1963–1967)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (1968). *Second Five-Year Development Plan [İkinci Beş Yıllık Kalkınma Planı] (1968–1972)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (1973). *Third Five-Year Development Plan [Üçüncü Beş Yıllık Kalkınma Planı] (1973–1977)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (1979). *Forth Five-Year Development Plan [Dördüncü Beş Yıllık Kalkınma Planı] (1979–1983)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (1984). *Fifth Five-Year Development Plan [Beşinci Beş Yıllık Kalkınma Planı] (1985–1989)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (1990). *Sixth Five-Year Development Plan [Altıncı Beş Yıllık Kalkınma Planı] (1990–1994)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (2000). *Eight Five-Year Development Plan [Sekizinci Beş Yıllık Kalkınma Planı] (2001–2005)*. Ankara.
- Devlet Planlama Teşkilatı (DPT). (2007a). *The situation of the elderly in Türkiye and the national plan of action on ageing [Türkiye'de yaşlıların durumu ve yaşlanma ulusal eylem planı]*. Sosyal Sektörel ve Koordinasyon Genel Müdürlüğü. Ankara.
- DPT – Devlet Planlama Teşkilatı (DPT). (2007b). *Ninth Development Plan [Dokuzuncu Kalkınma Planı] (2007–2013)*. Ankara.
- Dülger Türkoğlu, H., Bölen, F., Baran, P. K., & Marans, R. W. (2008). Measuring quality of life in Istanbul [İstanbul'da yaşam kalitesinin ölçülmesi]. *ITU Journal /a Architecture Planning Design [İTÜ Dergisi/a Mimarlık Planlama Tasarım]*, 7(2), 103–13.
- Eminaoğlu, Z., & Çevik, S. (2005). Evaluation of design and planning policies for rural settlements within a regional scale [Kırsal yerleşmelere ilişkin tasarım ve planlama politikalarının bölgesel ölçek içinde değerlendirilmesi]. *Planning Journal [Planlama Dergisi]*, 2005(2), 72–81.
- Eştürk, Ö. V., & Ören, M. N. (2014). Agricultural policies and food security in Türkiye [Türkiye'de tarım politikaları ve gıda güvencesi]. *YYÜ Tarım Bilimleri Dergisi [Van Yüzüncü Yıl University Journal of Agricultural Sciences]*, 24(2), 193–200. <https://doi.org/10.29133/yyutbd.235933>
- European Commission. (2013). *Support for rural development by the European Agricultural Fund for Rural Development (EAFRD)*. European Commission.
- Eurostat. (2015). *Quality of life*. Publications Office of the European Union.
- Geray, C. (1974). *Rural-oriented efforts during the planned period [Planlı dönemde köye yönelik çalışmalar]*. TO-DAİE Yayınları.
- Gregory, D., Johnston, R., Pratt, G., Watts, M., & Whatmore, S. (2009). *The dictionary of human geography* (5th ed.). Wiley-Blackwell.
- Gürçam, Ö. S., & Aydın, Ö. F. (2019). Türkiye's agricultural support policies from the founding of the Republic to the present [Cumhuriyet'in kuruluşundan günümüze Türkiye'nin tarımsal destekleme politikaları]. *Route Educational and Social Science Journal*, 6(8), 56–70. <https://doi.org/10.17121/ressjournal.2301>
- Kan, M., Kan, A., Nizami, D., Perkin, A. Y., Everest, B., & Taşcıoğlu, Y. (2020). The current situation and future of rural development practices in the world and in Türkiye [Dünyada ve Türkiye'de kırsal kalkınma uygulamalarındaki mevcut durum ve gelecek]. *Türkiye Ziraat Müh IX Tek Kongresi*. Ankara.
- Kayıkçı, S. (2005). Policies pursued toward villages and villages from the founding of the Republic to the present [Cumhuriyet'in kuruluşundan günümüze kadar köye ve köylüye yönelik olarak izlenen politikalar].

- Turkish Journal of Administration [Türk İdare Dergisi]*, 448, 69–100.
- Kılıç, S. (1997). *A study on rural development models implemented during the planned period [Planlı dönemde uygulanan kırsal kalkınma modelleri üzerine bir inceleme]* [Master's Thesis]. Ankara Üniversitesi.
- Kolodinsky, J. M., Desisto, T. P., Proppen, D., Putnam, M. E., Roche, E., & Sawyer, W. R. (2013). It is not how far you go, it is whether you can get there: Modeling the effects of mobility on quality of life in rural New England. *Journal of Transport Geography*, 31, 113–22. <https://doi.org/10.1016/j.jtrangeo.2013.05.011>
- Koutsouris, A., I. & Darnhofer, M. (2010). The emergence of the intra-rural digital divide: A critical review of the adoption of ICTs in rural areas and the farming community. In *Building sustainable rural futures: the added value of systems approaches in times of change and uncertainty*. 9th European IFSA Symposium, Vienna, Austria, 4-7 July 2010, (23–32).
- Küçüköğül, S., & Türkoğlu, H. (2021). A methodological proposal for measuring quality of life in rural settlements: Examples from villages in Bursa [Kırsal yerleşmelerde yaşam kalitesinin ölçülmesi için bir yöntem önerisi: Bursa köylerinden örnekler]. *Planning Journal [Planlama Dergisi]*, 31(1), 47–62.
- Malkina-Pykh, I. G., & Pykh, Y. A. (2008). Quality-of-life indicators at different scales: Theoretical background. *Ecological Indicators*, 8(6), 854–62. <https://doi.org/10.1016/j.ecolind.2007.01.008>
- Michalska-Żyła, A., & Marks-Krzyszowska, M. (2018). Quality of life and quality of living in rural communes in Poland. *European Countryside*, 10(2), 280–99. <https://doi.org/10.2478/euco-2018-0017>
- Nussbaum, M., & Sen, A. (1993). *The quality of life*. Clarendon Press. <https://doi.org/10.1093/0198287976.01.0001>
- OECD. (2011). *How's life?: Measuring well-being*. OECD Publishing.
- OECD. (2019). *OECD regional outlook 2019: Leveraging megatrends for cities and rural areas*. OECD Publishing.
- OECD. (2021). *Applying evaluation criteria thoughtfully*. OECD Publishing. <https://doi.org/10.1787/543e84ed-en>
- Polat, S. (2000). *Village-town and central village practices, village-towns/management and views on rural areas* [Unpublished Seminar Notes]. Mimar Sinan University.
- Rybakovas, E. (2016). Differentiate patterns of individually perceived quality of life in big cities, towns and rural areas. *Inžinerinė Ekonomika*, 27(5), 557–67. <https://doi.org/10.5755/j01.ee.27.5.14640>
- Sarı, V. İ., & Kındap, A. (2018). Analysis of urban quality of life indicators in Türkiye. [Türkiye'de kentsel yaşam kalitesi göstergelerinin analizi]. *Court of Accounts Journal [Sayıştay Dergisi]*, 108, 39–72.
- Soyak, A. (2003). Economic planning in Türkiye: Is there a need for the State Planning Organization (DPT) [Türkiye'de iktisadi planlama: DPT'ye ihtiyaç var mı?]. *Doğuş University Journal [Doğuş Üniversitesi Dergisi]*, 4(2), 167–82. <https://doi.org/10.31671/dogus.2019.316>
- Şahinöz, A. (2010). New agricultural policies in the new millennium [Yeni binyılda yeni tarım politikaları]. *Akdeniz Faculty of Economics and Administrative Sciences Journal [Akdeniz İİBF Dergisi]*, 19, 331–49.
- Taş, B. (2016). *Rural settlements of Türkiye [Türkiye'nin kırsal yerleşmeleri]*. Yeditepe Yayınevi.
- T. C. Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı. (2019). *Eleventh Development Plan [On Birinci Kalkınma Planı] (2019–2023)*. Ankara.
- T.C. Kalkınma Bakanlığı. (2014). *Tenth Five-Year Development Plan [Onuncu Beş Yıllık Kalkınma Planı] (2014–2018)*. Ankara.
- T.C. Tarım ve Orman Bakanlığı. (2019). *3rd Agriculture and Forestry Council Final Declaration [III. Tarım Orman Şurası Sonuç Bildirgesi]*. Ankara.
- T.C. Tarım ve Orman Bakanlığı. (2021). *National Rural Development Strategy [Ulusal Kırsal Kalkınma Stratejisi] (2021–2023)*. Ankara.
- T.C. Resmi Gazete. (2021, 15 Nisan). *Regulation on Rural Neighborhoods and Rural Settlement Areas [Kırsal Mahalle ve Kırsal Yerleşik Alan Yönetmeliği]*. Resmi Gazete, 31455.
- TÜİK. (2017). *Address-based population registration system 2017 results [Adrese dayalı nüfus kayıt sistemi 2017 sonuçları]*. Retrieved Oct 7, 2025, from <https://data.tuik.gov.tr/Bulten/Index?p=Adrese-Dayali-Nufus-Kayit-Sistemi-Sonuc-lari-2017-27587>
- TÜİK. (2021). *Türkiye kır/kent nüfus dağılımı 2021 [Urban-rural population distribution of Türkiye, 2021]*. Retrieved Oct 7, 2025, from <https://www.tuik.gov.tr/#>
- TÜİK. (2023). *Kent-kır nüfusu istatistikleri 2022 [Urban-rural population statistics, 2022]*. <https://data.tuik.gov.tr/Bulten/Index?p=Kent-Kir-Nufus-Istatistikleri-2022-49755>
- United Nations. (2002). *Report of the Second World Assembly on Ageing: Madrid, 8–12 April 2002 (Publication No. A/CONF.197/9)*. United Nations.
- United Nations Department of Economic and Social Affairs (UNDESA). (2023). *The Sustainable Development Goals Report 2023: Special Edition*. Retrieved Oct 7, 2025, from <https://unstats.un.org/sdgs/report/2023/>
- Üçdoruk, Ş. (2002). Analysis of internal migration in İzmir using the multinomial logit technique [İzmir'deki iç göç hareketinin çok durumlu logit tekniikle incelenmesi]. *Dokuz Eylül University Faculty of Economics and Administrative Sciences Journal [DEÜ İİBF Dergisi]*, 17(1), 157–83.

- Vaishar, A., & Stastna, M. (2019). Smart village and sustainability: Southern Moravia case study. *European Countryside*, 11(4), 651–60. <https://doi.org/10.2478/euco-2019-0036>
- Wardenburg, S., & Brenner, T. (2020). How to improve the quality of life in peripheral and lagging regions by policy measures? Examining the effects of two different policies in Germany. *Journal of Regional Science*, 60(5), 1047–73. <https://doi.org/10.1111/jors.12500>
- Wiesli, T. X., Liebe, U., Hammer, T., & Bar, R. (2021). Sustainable quality of life: A conceptualization that integrates the views of inhabitants of Swiss rural regions. *Sustainability*, 13(16), 9187. <https://doi.org/10.3390/su13169187>
- Wojewódzka-Wiewiórska, A., Kłoczko-Gajewska, A., & Sulewski, P. (2019). Between the social and economic dimensions of sustainability in rural areas—In search of farmers' quality of life. *Sustainability*, 12(1), 148. <https://doi.org/10.3390/su12010148>
- World Bank. (2003). *Reaching the rural poor: A renewed strategy for rural development*. World Bank.
- World Bank. (2010). *Scaling-up the impact of good practices in rural development: A working paper to support implementation of the World Bank's rural development strategy*. World Bank.
- World Health Organization (WHO). (1997). *WHOQOL measuring quality of life*. Retrieved Oct 7, 2025, from <https://www.who.int/tools/whoqol>
- Yenigül, S. B. (2016). The role of urban agriculture and local governments in the protection of agricultural land in metropolitan areas. [Büyükşehirlerde tarımsal alanların korunmasında kentsel tarım ve yerel yönetimlerin rolü]. *Megaron*, 11(2), 291–99.
- European Commission. (n.d.a). *Odlingsakademien – Cultivation Academy in Sweden*. Retrieved Oct 7, 2025, from https://ec.europa.eu/enrd/sites/default/files/project/attachments/enrd_odlingsakademien_-_cultivation_academy_in_sweden.pdf
- European Commission. (n.d.b). *Broadband 4 Our Community*. Retrieved Oct 7, 2025, from <https://ec.europa.eu/enrd/sites/default/files/project/attachments/digital-broadband4ourcommunity.pdf>
- European Commission. (n.d.c). *The most pessimistic town in Finland*. Retrieved Oct 7, 2025, from <https://ec.europa.eu/enrd/sites/default/files/project/attachments/social-the-most-pessimistic-town-in-finland.pdf>
- European Commission. (n.d.d). *Na-Tür-lich Dorf*. Retrieved Oct 7, 2025, from <https://ec.europa.eu/enrd/sites/default/files/project/attachments/green-na-tur-lich-dorf.pdf>
- European Commission. (n.d.e). *Giovani Dentro – Opportunities and challenges faced by youth in inner areas of Italy*. Retrieved Oct 7, 2025, from https://ec.europa.eu/enrd/sites/default/files/project/attachments/enrd_giovani_dentro_-_opportunities_and_challenges_faced_by_youth_in_inner_areas_of_italy.pdf
- TOKİ. (n.d.). *Tarımköyler*. Retrieved Oct 7, 2025, from <https://www.toki.gov.tr/tarimkoyler>



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M G A R O N

Article

Supervised machine learning for thermal comfort and energy efficiency: An evaluation for the indoor built environment

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ABSTRACT

The growing demand for energy-efficient and sustainable buildings has accelerated the exploration of advanced technologies to optimize thermal comfort and reduce energy consumption. Machine learning techniques, particularly supervised learning approaches, have shown strong potential to optimize HVAC control while maintaining comfort. However, existing studies are often fragmented, with limited integrated analyses of methodologies and applications, particularly in the context of diverse climates, building typologies, and occupant behaviors. This study addresses these gaps through a semi-systematic review of peer-reviewed studies applying supervised machine learning techniques for thermal comfort prediction and energy optimization. Using a transparent process involving Web of Science search, predefined inclusion/exclusion criteria, and Rayyan-assisted screening, 18 supervised learning articles were identified from an initial 603 records. These articles were categorized into tree-based models, regression-based models and neural networks. The review identifies critical gaps, such as the insufficient integration of real-time occupant behavior, limited applicability across diverse climatic conditions, and challenges in achieving a balance between energy efficiency and occupant comfort. Findings highlight the strengths of tree-based models in feature selection and real-time decision-making, the simplicity of regression-based models for controlled environments, and the adaptability of neural networks in complex, non-linear scenarios. Despite these advancements, limitations such as data scarcity, computational demands, and the lack of long-term validation persist. Addressing these challenges is essential for the development of robust and scalable machine learning-driven solutions. This study provides a roadmap for future research and practical applications, emphasizing the transformative potential of supervised machine learning techniques in achieving sustainable, energy-efficient, and occupant-centered building environments.

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INTRODUCTION

The increasing global demand for energy-efficient and sustainable buildings has driven the exploration of advanced technologies for optimizing thermal comfort and reducing energy consumption (Moshood et al., 2024).

As heating, ventilation, and air-conditioning (HVAC) systems account for a significant proportion of energy use in buildings (Gupta & Deb, 2022), there is a critical need to develop intelligent control systems capable of maintaining optimal indoor environments while minimizing energy costs (Halhouli Merabet et al., 2021). Supervised machine

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learning techniques have emerged as powerful tools in this domain (Essamlali et al., 2024). They provide data-driven approaches to predict and manage indoor thermal conditions. These methods enable dynamic adjustments in HVAC operations, ensuring a balance between energy efficiency and occupant comfort across diverse building typologies and climatic conditions (Zhou et al., 2023).

This study focuses on three supervised machine learning (ML) families that have demonstrated substantial promise in addressing challenges related to thermal comfort control and energy optimization. Researchers aim to enhance the adaptability and precision of HVAC systems by leveraging these models. These attributes make them responsive to both environmental variations and occupant behavior. Despite their advancements, the application of supervised machine learning techniques remains an evolving field, requiring a comprehensive understanding of their strengths, limitations, and practical implications. To address this need, a semi-systematic literature review was undertaken using explicit eligibility criteria, a Web of Science database search, Rayyan-assisted screening, and structured data extraction.

Aim of the study

The exploration of machine learning in thermal comfort prediction has produced a wide range of studies, but the fragmented nature of existing research leaves significant opportunities for synthesis and further innovation. Several previous studies have focused on reviewing thermal comfort prediction studies using machine learning algorithms. Qavidel Fard et al. (2022) conducted a systematic review focusing on ML applications in thermal comfort studies, emphasizing methods, performance, and challenges. However, their review identified a lack of focus on personal

comfort models and inadequate exploration of real-world applications, alongside challenges in feature selection and model evaluation. Similarly, Feng et al. (2022) reviewed data-driven methods for personal thermal comfort prediction, addressing experimental design and modeling techniques but found insufficient attention to inter- and intra-individual variability and limited integration of online learning techniques. Another review by Lala & Hagishima (2022) provided a unique perspective on thermal comfort for primary schools, focusing on children-specific challenges such as illogical votes, multiple comfort metrics, and class imbalance in machine learning prediction studies. Yet, they emphasized the absence of dedicated machine learning models for children, indicating a gap in integrating these insights into broader contexts. Arakawa Martins et al. (2022) systematically reviewed personal thermal comfort models but identified limited diversity in climatic conditions, building typologies, and participant demographics, coupled with challenges in standardizing predictive frameworks. Finally, Zhang et al. (2022) critically reviewed machine learning-based occupancy prediction models, linking energy efficiency and indoor environmental quality. However, their analysis highlighted gaps in integrating occupancy prediction with real-time HVAC optimization and the need for addressing perceived indoor air quality (IEQ) and thermal comfort jointly.

These reviews' findings emphasize the necessity for a review that synthesizes insights from supervised machine learning techniques in predicting indoor thermal comfort while addressing their limitations and bridging the identified gaps. Table 1 summarizes key review studies, highlighting their purposes and the research gaps identified. The present research aims to evaluate the effectiveness of supervised

Table 1. Summary of the recent review papers on machine learning in thermal comfort

Review Study	Purpose of the Review	Identified Gaps
(Qavidel Fard et al., 2022)	Systematic review of ML applications in thermal comfort to evaluate methods, performance, and challenges.	Lack of focus on personal comfort models, inadequate exploration of real-world applications, and challenges in feature selection and model evaluation.
(Feng et al., 2022)	Review of data-driven methods for personal thermal comfort prediction, focusing on experimental design, data collection, and modeling techniques.	Insufficient attention to inter- and intra-individual variability, data quality issues, and limited integration of online learning techniques.
(Lala & Hagishima, 2022)	Comprehensive review of thermal comfort in primary schools, addressing ML challenges specific to children.	Absence of dedicated ML models for children, challenges like illogical votes, and data imbalance in primary school thermal comfort prediction.
(Arakawa Martins et al., 2022)	Systematic review of personal thermal comfort models with a focus on predictive modeling processes.	Limited diversity in climate, building types, and participant demographics; challenges in standardizing predictive modeling frameworks.
(Zhang et al., 2022)	Critical review of ML-based occupancy prediction models for energy efficiency, air quality, and thermal comfort.	Gaps in integrating occupancy prediction with real-time HVAC optimization and limited studies addressing perceived IEQ and thermal comfort jointly.

machine learning techniques in optimizing energy use and maintaining thermal comfort within built environments. By categorizing and analyzing research articles into three ML approaches, the study explores methodologies, applications, and outcomes, seeking to:

- Elucidate the contributions of each machine learning approach to thermal comfort optimization.
- Identify and address limitations and inconsistencies in existing research.
- Provide actionable insights to advance sustainable building practices through machine learning-driven HVAC systems.

METHODOLOGY

This study adopted a semi-systematic review approach to balance transparency and reproducibility with a focused scope on supervised machine learning for indoor thermal comfort and energy optimization. The review followed a series of predefined steps to ensure the selection of high-quality and relevant literature, detailed as follows:

- **Data source and search strategy:** Articles indexed in the Web of Science Core Collection were selected as the data source due to its comprehensive indexing of peer-reviewed scientific publications, ensuring access to high-impact studies. A database search was performed using the keywords “Thermal Comfort” and “Machine Learning,” yielding 603 articles, without applying any year limit. This focused selection ensured methodological consistency and avoided redundancy across overlapping indexing platforms, which often contain identical records within this specialized research area. The choice of a single, high-quality source also enabled a transparent and reproducible workflow, emphasizing depth and reliability over breadth of coverage.
- **Inclusion and Exclusion Criteria:** Several inclusion and exclusion criteria were applied to refine the dataset. Inclusion criteria were peer-reviewed journal articles addressing indoor built environments, supervised machine learning models, and outcomes on indoor thermal comfort and/or energy demand. The initial exclusion criteria were review papers, non-English or non-open-access items, theses/abstracts/grey literature to maintain the focus on indoor built environments. The exclusion criteria for the first screening process were personal comfort systems (PCSs) relying on physiological data, outdoor thermal comfort (OTC), vehicle indoor environments, and other non-indoor built environment research. Then, for the second screening session, the studies using unsupervised learning, reinforcement learning, and hybrid ML methods were excluded. These criteria were established to ensure reproducibility and enable further research.
- **Screening:** From 603 records, total 354 records were excluded, which were 60 review studies, 114 proceeding papers, three non-English studies, and 177 non-open access papers. The remaining 249 records were imported into Rayyan, a collaborative systematic review tool, to enhance the efficiency of the screening process (Ouzzani et al., 2016). Abstracts of 249 records were screened based on the aforementioned inclusion and exclusion criteria. At this stage, 215 articles were excluded because they did not address supervised learning for indoor built environments. These comprised 93 studies on personal comfort systems (PCSs) relying on physiological data, 59 on outdoor thermal comfort (OTC), 36 on vehicle indoor environments, and 27 on other non-indoor built environment contexts. This refinement resulted in 34 research articles focusing on machine learning techniques applied to thermal comfort models and energy efficiency. A second round of screening was then conducted on the full texts of these 34 articles to retain only those employing supervised learning techniques. In this stage, 16 articles were excluded: Eight focused on unsupervised learning methods, five on reinforcement learning methods, and three on hybrid machine learning approaches. The second screening produced 18 included studies specifically employing supervised learning techniques for indoor thermal comfort (603 → 249 → 34 → 18). The decision to focus on supervised learning was based on its dominance and preference in the field (Han et al., 2023), given its ability to handle labeled data for predictive accuracy and its wide applicability in real-world HVAC systems. Other machine learning approaches, including unsupervised and reinforcement learning, while valuable, were less represented and often lacked the direct applicability to thermal comfort optimization within building environments (Zhang et al., 2022).
- **Data extraction and categorization:** After screening, the included studies were first categorized according to the type of supervised machine learning approach used to facilitate comparative analysis:
 - **Tree-Based Models:** These models, including Random Forest and Gradient Boosted Decision Trees, were evaluated for their interpretability and robustness in handling diverse datasets.
 - **Regression-Based Models:** Studies focusing on linear and non-linear regression techniques were analyzed for their simplicity and adaptability in predicting thermal comfort indices.
 - **Neural Network Applications:** Advanced neural network architectures, including Artificial Neural Networks (ANNs) and Physics-Informed Neural Networks (PiNNs), were reviewed for their ability to model complex, non-linear relationships.

Following this categorization, structured data extraction was undertaken for each included study in each category to ensure consistency and comparability. Predefined fields included context/building type, climate/geographical setting, dataset size and variables (environmental and occupant-related parameters), validation method (cross-validation, field testing, simulation-based), performance metrics (accuracy, F1-score, MAE, RMSE, energy savings), and energy/comfort outcomes (PMV, TSV, operative temperature, optimization levels, comfort improvements).

- Quality Assessment / Risk of Bias:** To evaluate the methodological quality and reliability of the included studies, the Prediction model Risk of Bias Assessment Tool (PROBAST) was adapted to the context of supervised machine learning in thermal comfort and energy optimization (Wolff et al., 2019). Each study was independently assessed across four domains, data and setting (D1), predictors and feature engineering (D2), outcomes/labels (D3), and analysis (D4), and rated as low, low-moderate, moderate, or high risk of bias. The applicability concerns were also rated and recorded a short justification for each judgment (Appendix Table A1). This approach ensured transparency and reproducibility in the evaluation of the included studies.
- Synthesis and comparative analysis:** A structured narrative synthesis was undertaken, organizing the included studies according to the three supervised machine learning approach groups and enabling systematic cross-study comparison of methods and outcomes. This process allowed the identification of patterns, methodological differences, and performance trends across the reviewed studies. The main analytical dimensions included:
 - Adaptability:** Assessing the ability of models to adjust to varying climates, building typologies, and occupant behaviors in real-time settings.
 - Challenges:** Identifying specific limitations such as insufficient real-time data processing or incomplete integration of occupant behavior.
 - Climate influence:** Examining how differences in climatic conditions affected optimization levels, highlighting areas where machine learning models underperform.

This synthesis and comparative analysis addressed critical questions such as whether the limitations stemmed from inadequate real-time data integration or inherent gaps in capturing occupant behavior. Thus, this approach provides a deeper understanding of the research landscape and identifies avenues for further development.

The structured selection process for the reviewed studies is illustrated in Figure 1, providing a visual representation of each searching stage, screening, and eligibility assessment, and categorization phase.

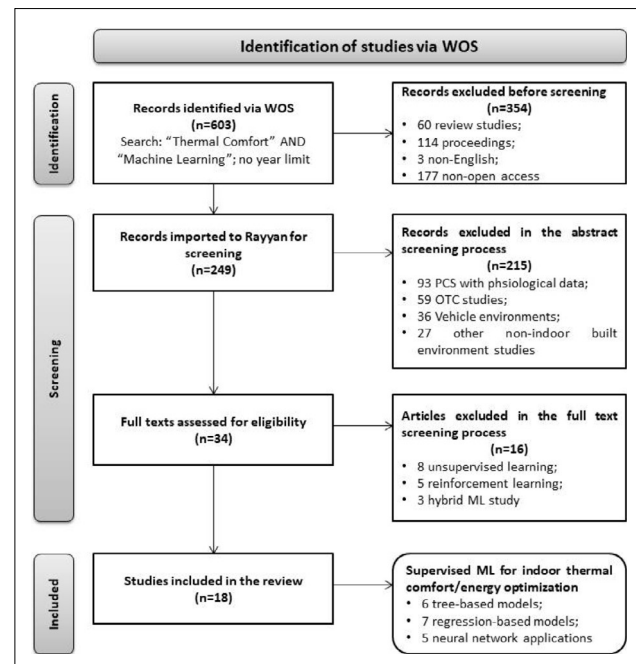


Figure 1. Flow chart of the selection strategy and categorization process.

RESULTS AND DISCUSSION

Categorization of supervised learning approaches

Supervised learning techniques have been widely used in the field of thermal comfort prediction and energy optimization within the built environment. These methods employ labeled data to establish predictive models that address diverse challenges such as real-time HVAC control, adaptive thermal comfort management, and efficient energy use. The reviewed studies are categorized into three primary approaches: Tree-based models, regression-based models, and neural network applications. Each category demonstrates distinct strengths and applications, from robust feature selection in tree-based models to the simplicity and interpretability of regression-based approaches, and the powerful adaptability of neural networks in handling complex, non-linear datasets. This section provides a detailed analysis of the selected articles under these categories, exploring their methodologies, applications, and outcomes, while also highlighting their contributions to addressing challenges in thermal comfort control and energy efficiency.

Tree-Based Models: Tree-based machine learning models have garnered attention for their ability to process complex datasets efficiently, offering robust feature selection and interpretability. This section details the methodologies and findings of six key studies that utilized tree-based approaches for thermal comfort and energy optimization. These studies denote the versatility of models such as Random Forest (RF), Gradient Boosted Decision Trees

(GBDT), and Decision Trees (DT) across different thermal comfort applications. Aparicio-Ruiz et al. focused on understanding indoor thermal comfort in Mediterranean climates using RF. This study emphasized the importance of an extended database with 21 variables, including indoor and outdoor parameters such as CO₂ levels and running mean temperature. By employing RF, the researchers achieved a 5% improvement in accuracy, illustrating the RF's capacity to handle diverse inputs and optimize conditioning systems for Mediterranean buildings (Aparicio-Ruiz et al., 2023). Similarly, Bai et al. compared the performance of RF and GBDT in predicting thermal preferences based on the ASHRAE Comfort Database II. Their ensemble learning approach demonstrated robust results, achieving weighted F1-scores more than 90%. The study also highlighted the influence of data characteristics like building type and season on model performance, showcasing the adaptability of tree-based models in varying contexts (Bai et al., 2022). On the other hand, Brik et al. integrated RF with Internet of Things (IoT) frameworks to create a real-time thermal comfort monitoring system. They achieved a prediction accuracy of 96% and reduced deviation from setpoints by 85% using data from a longitudinal study. Their study illustrated the synergy between IoT technologies and machine learning, offering insights into energy-efficient building management (Brik et al., 2022).

Hosamo et al. introduced an innovative application of RF within a digital twin framework to improve predictive maintenance and occupant comfort. The integration of Building Information Modelling (BIM) and real-time sensor data allowed for accurate detection of HVAC issues, reducing system failures by 10%. This study underlined

the potential of RF in advancing maintenance strategies and enhancing energy efficiency (Hosamo et al., 2023). In the study of Lu et al. RF model was applied to a combined radiant floor and fan coil cooling system, focusing on predicting operative temperature and energy consumption. Their findings demonstrated that RF outperformed other algorithms in error metrics, with reductions of up to 82% in mean squared error. The study emphasized the importance of machine learning in optimizing hybrid cooling systems, particularly in high-demand scenarios (Lu et al., 2024). Finally, Miao et al. developed an RF-based model tailored for naturally ventilated educational buildings. The study identified occupancy and ventilation practices as critical factors influencing thermal comfort. By leveraging accessible data, the researchers provided a cost-effective solution for schools, achieving robust generalization and practical applicability without the need for extensive sensor networks (Miao et al., 2023). These studies demonstrate the versatility and efficacy of tree-based models in addressing challenges related to thermal comfort and energy optimization. The details of the methodologies and findings are summarized in Table 2.

Regression-Based Models: Regression-based models serve as fundamental tools in predicting thermal comfort metrics by combining simplicity and interpretability. These models stand out in analyzing the relationships between environmental and personal factors with thermal comfort indices like Predicted Mean Vote (PMV) and Thermal Sensation Vote (TSV). This section synthesizes seven determined studies, their methodologies, and findings, elaborating on their contributions to this field. Abdellatif et al. presented a hybrid methodology integrating Multiple

Table 2. Summary of reviewed articles employing tree-based models

Study	Model	Application	Key Metrics	Outcomes
(Aparicio-Ruiz et al., 2023)	Random Forest	Thermal comfort prediction in Mediterranean climates	Accuracy Improvement: 5%	Enhanced model performance and variable relevance identification.
(Bai et al., 2022)	RF, GBDT	Thermal preference prediction	F1-Score: >90%	Superior performance of ensemble models with expanded datasets.
(Brik et al., 2022)	Random Forest	Real-time IoT-based thermal comfort monitoring	Accuracy: 96%, Optimization: 85%	Improved indoor comfort and real-time optimization capabilities.
(Hosamo et al., 2023)	Random Forest	Digital twin-based predictive maintenance	HVAC Failures Reduced: 10%	Enhanced occupant comfort and equipment lifespan through predictive strategies.
(Lu et al., 2024)	Random Forest	Hybrid cooling system energy and comfort prediction	MSE Improvement: 82%	Significant energy savings and predictive accuracy in hybrid cooling systems.
(Miao et al., 2023)	Random Forest	Educational building thermal comfort	Robust Generalization	Cost-effective prediction models for schools relying on natural ventilation.

Linear Regression (MLR) with genetic algorithms to optimize heating strategies for office buildings. By employing data from TRNSYS simulations, their approach achieved a 43% improvement in thermal comfort while maintaining energy efficiency. The genetic algorithm optimized heating parameters, demonstrating the utility of regression models in dynamic control systems (Abdellatif et al., 2022). Kumar & Kurian (2023) explored real-time thermal comfort prediction using Bayesian-optimized regression models. Their study developed predictive tools for PMV and Standard Effective Temperature (SET), leveraging automated feature selection techniques like Neighborhood Component Analysis. This model enhanced HVAC system responsiveness, yielding significant energy savings and improved user satisfaction through real-time environmental adjustments. Another study by Liu & Ma (2023) proposed an explainable Light Gradient Boosted Machine (LightGBM) regression model combined with SHAP analysis to assess thermal comfort across diverse Chinese climates. Their approach provided interpretable insights into the interactive effects of building and climatic variables, facilitating region-specific design optimizations aligned with energy conservation goal.

Mousavi et al. (2023) utilized meta-additive regression within a Green Building framework to optimize residential building envelopes in semi-arid climates. This study employed DesignBuilder simulations and statistical optimization to determine the most effective combinations of envelope parameters. Their methodology led to substantial annual energy reductions, emphasizing the adaptability of regression models in passive design strategies. Park et al. (2024) conducted a field test

integrating MLR within a thermal comfort controller (TCC) for residential HVAC systems. Their model utilized mean radiant temperature estimations to achieve real-time adjustments in HVAC settings, resulting in a 60% improvement in PMV and over 20% energy savings. This study highlighted the effectiveness of regression in real-world applications under dynamic climatic conditions. Similarly, Sibyan et al. (2022) compared MLR with machine learning approaches like Naive Bayes classifiers for thermal comfort prediction in naturally ventilated environments. The analysis demonstrated MLR's robustness despite simpler assumptions, validating its applicability in field studies and comparative analyses. Finally, Xi et al. (2024) applied linear regression to assess TSV in traditional Chinese dwellings. This study integrated field measurements and subjective surveys, identifying temperature ranges that aligned with historical and modern thermal comfort requirements. Their findings underscored the importance of contextual factors, such as cultural preferences and architectural heritage, in predictive modeling. These studies collectively underline the versatility of regression-based models in addressing thermal comfort challenges across various contexts. The methodologies and outcomes of these studies are detailed in Table 3.

Neural Network Applications: Artificial Neural Networks (ANNs) have emerged as a pivotal tool in advancing thermal comfort prediction and energy optimization within building management systems. By effectively modelling non-linear and complex relationships among environmental and personal parameters, ANNs demonstrate significant advantages in handling diverse datasets and achieving high predictive accuracy. In this section, the methodologies and

Table 3. Summary of reviewed articles employing regression-based models

Study	Regression Model	Application	Key Metrics	Outcomes
(Abdellatif et al., 2022)	Multiple Linear Regression	Heating optimization for indoor comfort	<1% Error, Adjusted R2: 0.9	43% improvement in thermal comfort, significant energy savings.
(Kumar & Kurian, 2023)	Bayesian-Optimized MLR	Real-time PMV and SET prediction	High Accuracy, Fast Response	Enhanced HVAC efficiency, real-time adaptability.
(Liu & Ma, 2023)	LightGBM Regression	Thermal comfort evaluation across climates	Accuracy with SHAP interpretations	Improved thermal designs for regional diversity.
(Mousavi et al., 2023)	Meta-Additive Regression	Envelope optimization in semi-arid climates	50% Energy Reduction	Optimal building design for energy and comfort enhancement.
(Park et al., 2024)	Linear Regression	Real-time HVAC control	PMV: +60%, Energy Savings: >20%	Improved comfort and efficiency in hot-dry climates.
(Sibyan et al., 2022)	Multiple Linear Regression	Comparison with ML methods	Higher Prediction Accuracy	Validated regression accuracy in field studies.
(Xi et al., 2024)	Linear Regression	TSV prediction for heritage dwellings	Accurate TSV Models	Novel insights for heritage building thermal comfort.

findings of five key studies that illustrate the application of ANNs are presented. Boutahri & Tilioua highlighted the predictive capabilities of ANNs in forecasting PMV values with enhanced accuracy, achieving an energy-saving potential of up to 32%. Their model incorporated real-time sensor data and was validated through comprehensive statistical error metrics such as Root Mean Square Error (RMSE) and Mean Absolute Error (MAE). The study underscored the adaptability of ANNs in smart buildings by integrating HVAC systems with predictive controls to balance energy consumption and occupant comfort (Boutahri & Tilioua, 2024). Similarly, Park & Woo investigated feature selection methods combined with ANNs to optimize PMV predictions. By utilizing Principal Component Analysis (PCA) and Best Subset selection, the research pinpointed the most influential variables for accurate and efficient PMV computation. The study achieved an impressive 89.7% accuracy, demonstrating the efficacy of ANNs in reducing computational loads while maintaining predictive precision (Park & Woo, 2023).

Pavirani et al. (2024) proposed a hybrid approach by integrating PiNNs with Monte Carlo Tree Search (MCTS) algorithms. This innovative combination enabled real-time control of residential heating systems while maintaining thermal comfort and reducing energy costs. The PiNNs incorporated physical constraints into the neural network model, offering a 7% improvement in thermal comfort and a 4% reduction in energy costs compared to traditional black-box neural networks (Pavirani et al., 2024). De la Hoz-Torres et al. 2024 applied ANNs to develop adaptive thermal comfort models for naturally ventilated educational buildings. Their research demonstrated the superiority of ANN-based models over traditional

PMV indices by achieving higher accuracy in thermal sensation predictions. The models were calibrated using data from a year-long monitoring campaign, revealing the significant role of adaptive behaviors in thermal comfort optimization. Lastly, Chegari et al. utilized ANNs within a surrogate-model framework to design nearly zero-energy buildings (NZEBs). This multi-objective optimization approach focused on enhancing thermal comfort and energy self-sufficiency, achieving an average improvement of 50% in comfort metrics. The surrogate model reduced computational requirements while maintaining robust performance across diverse climatic zones (Chegari et al., 2022). These studies collectively demonstrate the transformative potential of ANNs in advancing thermal comfort and energy optimization strategies. The detailed outcomes of these studies are given in Table 4.

Comparative Analysis of Energy Optimization and Comfort

The reviewed studies employing supervised machine learning techniques highlight their significant contributions to enhancing energy optimization and maintaining thermal comfort across diverse building typologies and climates. By comparing the methodologies and results across 18 selected papers, key insights can be drawn into the effectiveness and adaptability of these approaches. Tree-based models such as Random Forest (RF) and Gradient Boosted Decision Trees (GBDT) demonstrated a strong capacity for energy optimization, particularly in scenarios requiring robust feature selection and high interpretability. For example, Aparicio-Ruiz et al. showed a 5% gain in accuracy for TSV prediction in Mediterranean offices with RF by extending the variable set to 21 environmental and occupant parameters, including CO₂ and running mean

Table 4. Summary of reviewed articles employing neural network applications

Study	Neural Network Type	Application	Key Metrics	Outcomes
(Boutahri & Tilioua, 2024)	ANN	PMV prediction for HVAC optimization	Accuracy (96.7% R ²), RMSE	Improved thermal comfort and energy savings in smart buildings.
(Park & Woo, 2023)	ANN with PCA	PMV dimension reduction and prediction	89.7% Accuracy, PCA Analysis	Enhanced prediction speed and accuracy by selecting key PMV parameters.
(Pavirani et al., 2024)	Physics-informed NN	Demand response and heating control	-32% MAE, -4% energy cost	Effective control with reduced computational demands using PiNN.
(de la Hoz-Torres et al., 2024)	ANN	Adaptive thermal comfort in classrooms	Improved accuracy over PMV, enhanced PMV (ePMV)	Adaptive models better suited for naturally ventilated educational buildings.
(Chegari et al., 2022)	ANN	Surrogate model for NZEB design	50% improvement in comfort metrics	Multi-objective optimization enhanced thermal comfort and energy efficiency.

temperature (Aparicio-Ruiz et al., 2023). Similarly, Brik et al. integrated RF with IoT networks to provide real-time monitoring and control, reporting 96% prediction accuracy and an 85% improvement in indoor parameter adjustment, which translated into faster restoration of comfort after disturbances (Brik et al., 2022). Lu et al. showed that RF outperformed CNN, LSTM, SVM, radial basis function (RBF) and genetic algorithm–backpropagation (GA-BP) in a hybrid radiant floor/fan-coil cooling testbed, reducing MSE by 82%, MAE by 43%, and MAPE by 68% compared with other algorithms while maintaining $R > 0.99$ (Lu et al., 2024). RF also proved highly scalable in naturally ventilated schools when combined with class weighting and low-cost sensor inputs (Miao et al., 2023) highlighting its robustness under constrained data regimes. These models distinguish themselves in scenarios requiring immediate decision-making, such as hybrid cooling systems and educational buildings, by balancing energy savings with real-time thermal comfort adjustments. However, they are less suited to highly complex datasets with dynamic, non-linear interactions, as these require more adaptive learning techniques.

Regression-based models, while simpler, provided useful information for the linear relationships between environmental variables and thermal comfort indices like PMV and TSV, especially under controlled conditions. Abdellatif et al. utilized MLR with a genetic optimizer, forecasting indoor heating with lower than 1% error (adjusted $R^2 \approx 0.9$) and achieving 43% improvement in thermal comfort over a conventional strategy (Abdellatif et al., 2022). Kumar & Kurian's (2023) Bayesian-optimized regression achieved rapid, real-time PMV and SET predictions and temperature-setpoint control, delivering measurable energy savings and higher user satisfaction in HVAC offices. Park et al. (2024) demonstrated in a field test that integrating mean radiant temperature into a thermal comfort controller yielded a 60% reduction in PMV unmet hours and more than 20% energy savings. Yet, the inherent simplicity of regression-based approaches limited its performance in contexts with large adaptive variability or strong non-linear effects, such as naturally ventilated buildings or heritage structures, where RMSEs and comfort gains lagged behind tree-based or ANN approaches.

Neural network applications stood out for their adaptability and precision in handling complex, non-linear datasets. This makes them highly effective in real-time thermal comfort control. For instance, Boutahri & Tilioua achieved a R^2 of 96.7% and significant energy savings (nearly 32%) using ANNs for PMV forecasting in smart buildings, demonstrating significant energy savings without compromising occupant comfort (Boutahri & Tilioua, 2024). De la Hoz-Torres et al. created adaptive ANN comfort models for naturally ventilated educational buildings that outperformed traditional methods by integrating real-time environmental

and occupant data (de la Hoz-Torres et al., 2024). Chegari et al.'s ANN surrogate model for nearly zero-energy buildings improved thermal comfort metrics by nearly 50% while reducing energy demand substantially (Chegari et al., 2022), and Pavirani et al. (2024) showed that a physics-informed neural network (PiNN) coupled with Monte Carlo Tree Search produced 32% lower MAE in thermal forecasting, 7% comfort improvement and 4% energy cost reduction over a black-box NN (Pavirani et al., 2024). Park & Woo (2023) further demonstrated that combining PCA and best-subset selection with ANN achieved 89.7% accuracy on reduced-dimension PMV, cutting computational load without sacrificing predictive precision. These examples show that, although computationally demanding, neural networks excel in contexts requiring adaptation to occupant behavior, dynamic climates and multi-objective energy–comfort balance.

Cross-model comparisons across the 18 studies reveal a clear hierarchy of suitability under different operational and climatic conditions. Tree-based ensembles (RF, GBDT, LightGBM) provide the most acceptable balance of predictive accuracy, interpretability and computational efficiency in feature-rich but moderately dynamic settings, particularly hybrid HVAC systems, IoT deployments and digital-twin maintenance frameworks. For example, RF reduced MSE by 82 % and MAE by 43% in a hybrid radiant-floor/fan-coil system (Lu et al., 2024) and maintained $R^2 > 0.99$, while class-weighted RF models in naturally ventilated schools achieved robust performance without dense sensor networks (Miao et al., 2023). These results indicate that tree-based methods are especially advantageous where real-time decisions must be combined with variable importance screening and low-latency response. Regression-based approaches, though inherently linear, remain valuable when data complexity is low and model transparency is essential. They excel in controlled HVAC settings, offering fast convergence and interpretable parameters, as demonstrated by Abdellatif et al. (less than 1% forecast error and 43% comfort improvement) and Park et al. (2024) (60% fewer unmet PMV hours and more than 20% energy savings) in field trials. However, the comparative RMSE and comfort gains in naturally ventilated or heritage contexts consistently lag behind tree-based or ANN approaches, underscoring their limited capacity to model adaptive occupant behavior and multi-factor interactions. Neural networks and hybrid physics-informed variants clearly deliver the lowest RMSE and the highest comfort gains in real-time, adaptive contexts such as naturally ventilated schools, heritage dwellings and demand-response heating control. Boutahri & Tilioua reported R^2 of nearly 0.97 and approximately 32% of energy savings; Chegari et al. achieved about 50% improvement in comfort metrics in nearly zero-energy buildings; and Pavirani et al. (2024) demonstrated 32% lower MAE, 7%

comfort gain and 4% cost reduction with PiNN-based control. Park & Woo (2023) further showed that feature selection (PCA, Best Subset) enables ANNs to reach nearly 90% accuracy with reduced input dimensions, alleviating computational burden while retaining predictive power.

To further clarify these performance relationships, a visual synthesis was developed based on representative quantitative outcomes reported across the reviewed studies. Figure 2 provides a comparative summary of these results, emphasizing the relative patterns of error reduction, energy savings, and comfort accuracy among tree-based, regression-based, and neural-network approaches. The figure presents an indicative comparison, as it reflects the characteristic performance ranges drawn from key representative works (Aparicio-Ruiz et al., 2023; Bai et al., 2022; Brik et al., 2022; Lu et al., 2024; Miao et al., 2023; Abdellatif et al., 2022; Kumar & Kurian, 2023; Park et al., 2024; Boutahri & Tilioua, 2024; Chegari et al., 2022; Pavirani et al., 2024; de la Hoz-Torres et al., 2024). Displayed values illustrate the relative magnitude of error reduction, energy savings, and comfort accuracy reported in the literature.

Collectively, these findings show that ANNs outperform tree-based and regression methods when non-linearity, occupant adaptation and multi-objective energy–comfort balance dominate. Across all model types, integrating real-time occupant behavior and environmental data emerged as the single strongest predictor of stable accuracy and energy savings. Studies omitting such inputs consistently reported higher errors or weaker generalization. This synthesis demonstrates that supervised learning approaches are not interchangeable but rather scenario-specific tools:

- RF and LightGBM excel in rapid, interpretable decisions with heterogeneous data streams;
- regression-based models are suited to stable, quasi-linear regimes;
- ANNs or PiNNs are indispensable for non-linear, occupant-centered and multi-objective optimization contexts.

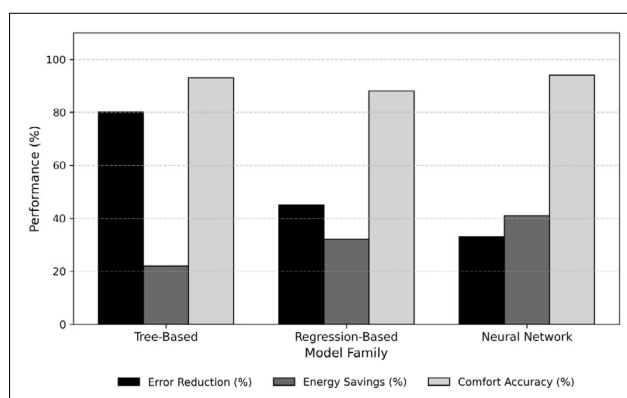


Figure 2. Comparative performance synthesis of supervised learning model families.

Identified Research Gaps

While supervised machine learning techniques have demonstrated significant potential in advancing energy optimization and thermal comfort within the built environment, several research gaps remain, limiting their widespread application and effectiveness. The review of selected studies reveals critical areas that require further investigation to address current limitations and advance the state of the art.

Integration of Real-Time Occupant Behavior

Many studies, particularly those employing regression-based and tree-based models, fail to fully integrate real-time occupant behavior into their predictive frameworks. For instance, models developed by Bai et al. and Aparicio-Ruiz et al. relied heavily on static environmental parameters, overlooking dynamic behavioral patterns such as adaptive actions or occupancy changes (Aparicio-Ruiz et al., 2023; Bai et al., 2022). This gap suggests the need for models that incorporate occupant interactions with their environments, particularly in naturally ventilated or mixed-mode buildings. To move the field forward, future work should (i) develop standardized behavior taxonomies (e.g., window/door operations, clothing adjustment, local fan/heater use) and minimal sensing protocols that can be replicated across buildings; (ii) fuse occupant-event streams with IEQ data for sequence-aware models (e.g., RF/LightGBM with lag features; LSTM/Temporal CNNs; hybrid PiNNs) and report incremental error reduction attributable to behavior; and (iii) publish ablation studies that quantify how much each behavior class improves RMSE/MAE and energy-comfort trade-offs. Such studies would directly test, in the same manner as Miao et al. (2023) and Park et al. (2024), whether adding behavior signals yields statistically significant gains over environment-only baselines.

Limited Focus on Diverse Climates and Building Typologies

The studies predominantly address specific climates or building types, such as Mediterranean climates (Aparicio-Ruiz et al., 2023) or educational buildings (Miao et al., 2023). Few have extended their applications to a broader range of climates or typologies, such as heritage buildings or high-performance green buildings. This limitation restricts the generalizability and scalability of the findings, underlining the need for research exploring diverse climatic and architectural contexts. A community benchmark of multi-climate, multi-typology datasets (e.g., classrooms, offices, heritage dwellings, NZEBs) with harmonized labels (PMV/TSV/ePMV) and common splits for external validation is recommended. Protocols should require reporting per-climate and per-typology performance, enabling fair cross-study comparisons similar to Liu & Ma, 2023 and Xi et al. (2024). Model cards should include “applicability statements” that explicitly state validated Köppen–Geiger zones and building archetypes.

Data Scarcity and Model Robustness

Several studies highlighted the challenges of acquiring high-quality, comprehensive datasets. For instance, Hosamo et al. 2023 and Brik et al. 2022 relied on IoT networks, which, while effective, are resource-intensive and not universally accessible. Additionally, many models were tested on limited datasets, raising concerns about their robustness and applicability in real-world scenarios. Future studies should focus on developing models that are robust to incomplete or noisy data and leverage innovative data augmentation techniques. Concrete next steps include: (i) Adopting nested cross-validation and leakage-safe feature selection to improve reliability across all three families (as issues were noted in multiple papers); (ii) stress-test models under missingness and sensor drift; and (iii) employing transfer learning/domain adaptation between climates and building types (e.g., training in Mediterranean offices and adapting to NV schools) with explicit reporting of adaptation gains. Open baselines should include LightGBM/RF, linear models, and at least one ANN to anchor robustness claims.

Evaluation practice deficiencies

Across the corpus, nested cross-validation and external validation were uncommon. When hyper-parameter tuning, feature selection, or preprocessing (imputation, scaling, resampling) are performed outside a nested scheme or on the full dataset, information leakage can inflate accuracy and understate uncertainty. Likewise, evaluating only on the same sites or periods used for development risks optimism and weakens claims of generalizability. Minimum leakage-safe practice should include repeated nested k-fold CV (all modeling operations confined to inner folds) and an external test via site-out or time-split protocols (different buildings, seasons, or terms). Reporting should add calibration metrics, fold-wise variance, and failure modes observed under robustness checks. Adopting these standards will immediately improve the credibility and comparability of results across model families.

Real-Time Processing and Adaptability

Neural network-based studies, such as those by Boutahri & Tilioua and De la Hoz-Torres et al., demonstrated strong adaptability but often required substantial computational resources (Boutahri & Tilioua, 2024; de la Hoz-Torres et al., 2024). These models struggle with real-time processing in low-resource environments, particularly in remote or economically constrained areas. Addressing this limitation by optimizing algorithms for computational efficiency or leveraging edge computing could make these methods more accessible and practical. Future research should (i) benchmark latency, memory, and power on representative edge hardware; (ii) evaluate model compression (quantization/pruning/knowledge distillation) and feature reduction (as in Park & Woo, 2023) with comfort/energy accuracy retained; and (iii) report end-to-end control-loop

stability (response time to setpoint changes, overshoot/undershoot) alongside prediction metrics.

Beyond raw accuracy, the real-world applicability of ANN/PiNN approaches is shaped by total cost of ownership and operational risk. Training often depends on specialized accelerators and curated pipelines, while inference on site can exceed the latency, memory, and power envelopes of legacy BMS or low-cost edge controllers; cloud off-loading adds recurring costs, privacy/compliance concerns, and network fragility. Scaling across buildings also requires site-specific calibration and continuous monitoring for drift, with nontrivial data quality checks, re-training, versioning, and rollbacks. Limited transparency can slow operator troubleshooting when comfort or IAQ alarms trigger, reducing trust compared with simpler, interpretable controllers. A pragmatic stance is to prefer compact tree ensembles or linear controllers when ANN gains are marginal or budgets are constrained, reserving ANN/PiNN solutions for strongly non-linear, occupant-adaptive contexts where demonstrated energy/comfort benefits outweigh compute and maintenance costs. When ANNs are deployed, studies should include simple guardrails on set-point changes, document fail-safe modes for sensor/connectivity faults, and report measured latency, memory, and power for the compressed/distilled model on the target edge device to demonstrate field readiness.

Balancing Energy Savings with Thermal Comfort

While energy optimization is an important focus, few studies explicitly quantify the trade-offs between energy savings and thermal comfort. For example, the works by Kumar & Kurian (2023) and Mousavi et al. (2023) emphasized energy savings but provided limited insights into how these savings impact occupant comfort under varying conditions. Future research should aim to establish a clearer balance between these objectives, incorporating adaptive comfort models that prioritize human well-being without significant energy penalties. For explicit multi-objective formulations with Pareto fronts (comfort vs. kWh/cost), reporting dominated vs. non-dominated solutions and sensitivity to seasonal/occupancy regimes is beneficial. Studies like Pavirani et al. (2024) and Chegari et al. (2024) provide templates; forthcoming work should standardize comfort violation metrics (e.g., unmet PMV/TSV hours, ePMV bands) and quantify comfort “cost” per unit energy saved.

Integration with Emerging Technologies

Most studies reviewed did not explore the integration of supervised learning techniques with emerging technologies such as digital twins, advanced IoT frameworks, or blockchain for data security and decentralization. The work by Hosamo et al. (2023) on digital twins stands as a notable exception but highlights the potential for combining machine learning with advanced technologies to enhance predictive accuracy, energy efficiency, and comfort

management. Future work should couple calibrated digital twins with supervised learning for fault diagnostics and proactive control, evaluating whether twin-in-the-loop supervision reduces failure rates and comfort violations beyond RF-only baselines (as hinted by Hosamo et al., 2023). Data governance should be addressed via privacy-preserving pipelines (federated learning, differential privacy) to enable cross-site generalization without sharing raw occupant data.

Long-Term Validation Studies

Many studies evaluated their models using short-term datasets or simulations, with limited validation in real-world, long-term operational settings. For example, Lu et al. (2024) demonstrated energy savings in hybrid cooling systems but lacked long-term empirical data to substantiate these findings under varying operational conditions. Longitudinal studies that track model performance over extended periods are needed to validate their reliability and effectiveness. More than 12-month deployments spanning seasons and occupancy cycles, with pre-registered analysis plans, drift detection, and periodic re-calibration rules are recommended. Reports should include durability of gains (R2/MAE stability, comfort violations, energy bills) and failure mode analyses (sensor outages, occupancy anomalies).

Equity and Accessibility Considerations

A recurring gap is the lack of focus on making these technologies accessible in economically constrained or developing regions. Models relying on high-cost infrastructure, such as IoT networks or advanced computational systems, are less applicable in these settings. Research aimed at creating cost-effective and scalable solutions, like the RF-based model by Miao et al. (2023), could address this inequity. Priorities include low-cost sensing kits, sparse-feature models that maintain accuracy with minimal inputs, and edge-deployable controllers. Studies should report a “cost-to-accuracy” curve and provide open designs/bills of materials so that public schools and small offices can reproduce the results.

In sum, the empirical patterns across the 18 studies suggest a pathway for targeted progress: (1) Add behavior signals and temporal structure to supervised models; (2) validate across climates/typologies using shared benchmarks; (3) enforce leakage-safe evaluation (nested CV, external tests) and robustness checks; (4) operationalize real-time constraints on edge hardware; (5) optimize explicitly on the comfort-energy Pareto frontier; (6) integrate digital-twin supervision and privacy-preserving data pipelines; (7) extend evaluations to multi-season deployments; and (8) prioritize low-cost, reproducible solutions. Addressing these items will convert today’s promising but fragmented results into generalizable, field-ready ML frameworks that reliably balance energy efficiency and occupant comfort.

Strategies for Progress: Practical Implications

The limitations identified in Section 3.3 are not isolated shortcomings but stem from recurring structural and methodological challenges within the current research landscape. Recognizing the underlying reasons for these shortcomings and proposing practical strategies to address them can accelerate progress in supervised machine learning for thermal comfort and energy efficiency. A first and persistent limitation arises from the restricted data coverage and quality of existing studies. Many models are developed from single buildings, limited climates, or short monitoring periods. This narrow scope limits the diversity of environmental conditions, occupant behaviors, and building typologies captured in the datasets. As a result, models often lack external validity and show performance drops when applied to new settings. Addressing this gap requires coordinated efforts to build multi-site and multi-season datasets with harmonized comfort indices, consistent sensor metadata, and clear contextual variables such as occupancy schedules or ventilation strategies. When such large-scale data collection is not feasible, researchers can still improve reliability through nested cross-validation, leakage-safe feature selection, and data augmentation or simulation of unobserved conditions. By stress-testing models under missing data or sensor drift, studies can quantify robustness before deployment.

Another major cause of current shortcomings is the limited integration of occupant behavior into predictive frameworks. Most models rely heavily on environmental variables and treat occupants as passive recipients of indoor conditions. Yet evidence from adaptive comfort research shows that actions such as window opening, clothing adjustment, or use of local fans can substantially shift comfort thresholds. A key strategy is to develop standardized, low-cost protocols for capturing occupant actions, either through simple binary sensors or self-reports linked to time-stamped environmental data. These behavioral event streams can then be incorporated into supervised models as lagged or sequential features, or through temporal and sequence-aware architectures such as LSTMs, temporal CNNs, or hybrid physics-informed neural networks. Publishing ablation studies that explicitly compare environment-only models with behavior-enhanced models would help quantify the added value and set benchmarks for future work.

A third limitation stems from generalizing across climates and building typologies. Most models have been validated only in Mediterranean offices, naturally ventilated schools, or similar narrow archetypes. This raises the risk that models encode climate-specific correlations rather than universal principles. Researchers can overcome this by developing and sharing multi-climate benchmark datasets with fixed training–testing splits, and by reporting performance separately for each climate zone and building archetype.

Domain adaptation and transfer-learning methods can be tested explicitly (for example, training on Mediterranean offices and adapting to educational buildings in temperate zones) with reported adaptation gains. Model “applicability statements” could then state validated Köppen–Geiger zones and archetypes, improving transparency for practitioners.

Computational constraints also play a key role. High-capacity neural networks offer excellent accuracy but may be too resource-intensive for real-time, edge-level control. Without careful attention to latency, memory, and power, these models cannot be integrated into HVAC controllers or low-cost sensing platforms. Strategies include model compression techniques such as quantization, pruning, or knowledge distillation, combined with feature-reduction approaches to lower input dimensionality while retaining predictive power. Benchmarking models on representative embedded hardware, and reporting end-to-end control loop metrics such as response time and overshoot, would make research outcomes far more actionable for practitioners.

Another widespread shortcoming is the one-sided focus on either comfort or energy without explicitly quantifying trade-offs. This obscures the true cost of achieving comfort gains or energy savings. Future work should adopt multi-objective optimization frameworks to map Pareto fronts of comfort versus energy, and employ standardized comfort violation metrics such as unmet PMV or TSV hours. Reporting comfort “cost per unit energy saved” and seasonal sensitivity analyses would help designers and operators choose balanced strategies and compare across studies. This approach transforms models from black-box predictors into decision-support tools with clear operational implications.

Finally, issues of data governance, privacy, and reproducibility constrain the cross-site validation needed for robust models. Sharing raw occupant or environmental data across institutions is often impractical or unethical. Emerging privacy-preserving methods such as federated learning or differential privacy can allow multiple sites to train a shared model without exchanging raw data. Accompanying open-source code, baseline models, and clear reporting checklists (including dataset splits, leakage tests, and calibration metrics) will further strengthen reproducibility and accelerate uptake. Together, these strategies form a coherent roadmap for converting today’s promising but fragmented studies into reliable, scalable tools for building practice. By combining broader, higher-quality datasets with behavior-aware features, multi-climate benchmarking, edge-ready model designs, explicit multi-objective optimization, and privacy-preserving collaboration, the field can move beyond narrow proofs of concept to deliver field-ready, occupant-centered, energy-efficient control systems. In practical terms, this means HVAC systems capable of dynamically adapting to both environmental changes and human actions, design recommendations grounded in diverse climates

and typologies, and machine learning models that can be deployed even in low-resource settings. Ultimately, such advances will help translate the theoretical potential of supervised machine learning into widespread real-world impact, supporting carbon reduction, improved occupant well-being, and the broader goals of sustainable architecture and urban development.

CONCLUSION

This study employed a semi-systematic review to examine the application of supervised learning approaches in thermal comfort prediction and energy optimization within the built environment, using a transparent and replicable search, and screening process. By categorizing the reviewed studies into tree-based models, regression-based models, and neural network applications, their unique strengths, methodological contributions, and practical applications were highlighted.

Tree-based models, such as Random Forest and Gradient Boosted Decision Trees, stand out in interpretability and feature selection, which makes them effective tools for real-time decision-making in hybrid systems and IoT-enhanced frameworks. Regression-based models, characterized by their simplicity and linear focus, are highly suited for controlled environments and scenarios requiring efficient and scalable solutions. Neural networks demonstrated good adaptability and precision, particularly in dynamic, non-linear scenarios requiring real-time adjustments, such as naturally ventilated or smart buildings. Supervised learning approaches collectively showed a substantial potential in improving building energy efficiency and occupant comfort. Neural network models, in particular, consistently delivered high accuracy and adaptability, enabling significant energy savings while maintaining or enhancing thermal comfort. However, tree-based and regression models remain valuable alternatives in contexts with constrained computational resources or data availability, providing practical and scalable solutions. Synthesizing across these strands, several practice-oriented takeaways emerge:

- In practice, selecting the model family to fit the operational context yields the best results, with tree ensembles balancing accuracy and interpretability in feature-rich yet moderately dynamic settings, regression suiting simple and transparent control, and ANNs/PiNNs excelling in strongly non-linear, occupant-adaptive scenarios.
- With appropriate configuration and validation, supervised models can deliver measurable energy savings without degrading thermal comfort.
- Incorporating real-time occupant actions and contextual variables improves generalization across climates and building typologies.

- Leakage-safe pipelines with repeated nested cross-validation plus external tests are essential for reliable, comparable claims across model families.
- Deployment constraints (compute, latency, power, maintainability) often favor compact ensembles or compressed neural networks on edge hardware, supplemented by guardrails and fail-safes for closed-loop control.

The study identified several critical research gaps and methodological limitations that constrain the broader application of these techniques. Key gaps include the limited integration of real-time occupant behavior, insufficient focus on diverse climatic and building typologies, challenges in data availability and model robustness, and the trade-offs between energy savings and occupant comfort. The lack of long-term validation studies and limited integration with emerging technologies, such as digital twins and edge computing, further underscore the need for advanced research efforts. In addition, as a semi-systematic review with a defined search scope and standardized inclusion criteria, the analysis is inherently bounded by its database coverage and screening framework. Although every effort was made to ensure transparency and replicability, the reliance on a single indexing source and the absence of a formal risk-of-bias appraisal may have led to the omission of a small number of relevant studies. This focused approach was adopted to maintain methodological consistency, clarity, and reproducibility while minimizing redundancy among overlapping indexing platforms. Future reviews may broaden the search scope as the field expands and diversifies.

Acknowledging both research gaps and methodological constraints provides a transparent basis for interpreting the findings and highlights opportunities for future work to develop more inclusive, robust, and scalable machine learning-based solutions. As a minimum good-practice standard, future studies should report repeated nested cross-validation (with all modeling operations inside folds) together with an external validation on independent sites or time windows, alongside calibration and robustness analyses. The practical implications of this research offer that machine learning-driven HVAC systems represent a transformative approach to sustainable building practices, enabling buildings to dynamically adapt to changing conditions while balancing energy efficiency and human comfort. These systems have the potential to reduce energy consumption, lower operational costs, and enhance occupant well-being, contributing to global efforts toward carbon neutrality and sustainable development. As technology and computational capabilities advance, the integration of supervised learning in HVAC systems and thermal comfort management will likely play an essential role in shaping the future of energy-efficient and human-centered architecture.

Appendix: [https://jag.journalagent.com/megaron/abs_files/MEGARON-02256/MEGARON-02256 \(2\) Appendix Table A1.pdf](https://jag.journalagent.com/megaron/abs_files/MEGARON-02256/MEGARON-02256 (2) Appendix Table A1.pdf)

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REFERENCES

- Abdellatif, M., Chamoin, J., Nianga, J. M., & Defer, D. (2022). A thermal control methodology based on a machine learning forecasting model for indoor heating. *Energy and Buildings*, 255, 111692. <https://doi.org/10.1016/j.enbuild.2021.111692>
- Aparicio-Ruiz, P., Barbadilla-Martín, E., Guadix, J., & Nevado, J. (2023). Analysis of variables affecting indoor thermal comfort in Mediterranean climates using machine learning. *Buildings*, 13(9), 2215. <https://doi.org/10.3390/buildings13092215>
- Arakawa Martins, L., Soebarto, V., & Williamson, T. (2022). A systematic review of personal thermal comfort models. *Building and Environment*, 207, 108502. <https://doi.org/10.1016/j.buildenv.2021.108502>
- Bai, Y., Liu, K., & Wang, Y. (2022). Comparative analysis of thermal preference prediction performance in different conditions using ensemble learning models based on ASHRAE Comfort Database II. *Building and Environment*, 223, 109462. <https://doi.org/10.1016/j.buildenv.2022.109462>
- Boutahri, Y., & Tilioua, A. (2024). Machine learning-based predictive model for thermal comfort and energy optimization in smart buildings. *Results in Engineering*, 22, 102148. <https://doi.org/10.1016/j.rineng.2024.102148>
- Brik, B., Esseghir, M., Merghem-Boulahia, L., & Hentati, A. (2022). Providing convenient indoor thermal comfort in real-time based on energy-efficiency IoT network. *Energies*, 15(3), 808. <https://doi.org/10.3390/en15030808>
- Chegar, B., Tabaa, M., Simeu, E., Moutaouakkil, F., & Medromi, H. (2022). An optimal surrogate-model-based approach to support comfortable and nearly zero energy buildings design. *Energy*, 248, 123584. <https://doi.org/10.1016/j.energy.2022.123584>
- de la Hoz-Torres, M. L., Aguilar, A. J., Ruiz, D. P., & Martínez-Aires, M. D. (2024). An investigation of indoor thermal environments and thermal comfort

- in naturally ventilated educational buildings. *Journal of Building Engineering*, 84, 108677. <https://doi.org/10.1016/j.jobe.2024.108677>
- Essamlali, I., Nhaila, H., & El Khaili, M. (2024). Supervised machine learning approaches for predicting key pollutants and for the sustainable enhancement of urban air quality: A systematic review. *Sustainability*, 16(3), 976. <https://doi.org/10.3390/su16030976>
- Feng, Y., Liu, S., Wang, J., Yang, J., Jao, Y. L., & Wang, N. (2022). Data-driven personal thermal comfort prediction: A literature review. *Renewable and Sustainable Energy Reviews*, 161, 112357. <https://doi.org/10.1016/j.rser.2022.112357>
- Gupta, V., & Deb, C. (2022). Energy retrofit analysis for an educational building in Mumbai. *Sustainable Futures*, 4, 100096. <https://doi.org/10.1016/j.sfsr.2022.100096>
- Halhouli Merabet, G., Essaaïdi, M., Ben Haddou, M., Qolomany, B., Qadir, J., Anan, M., Al-Fuqaha, A., Abid, M. R., & Benhaddou, D. (2021). Intelligent building control systems for thermal comfort and energy-efficiency: A systematic review of artificial intelligence-assisted techniques. *Renewable and Sustainable Energy Reviews*, 144, 110969. <https://doi.org/10.1016/j.rser.2021.110969>
- Han, X., Hu, Z., Li, C., Wu, J., Li, C., & Sun, B. (2023). Prediction of human thermal comfort preference based on supervised learning. *Journal of Thermal Biology*, 112, 103484. <https://doi.org/10.1016/j.jtherbio.2023.103484>
- Hosamo, H. H., Nielsen, H. K., Kraniotis, D., Svennevig, P. R., & Svidt, K. (2023). Improving building occupant comfort through a digital twin approach: A Bayesian network model and predictive maintenance method. *Energy and Buildings*, 288, 112992. <https://doi.org/10.1016/j.enbuild.2023.112992>
- Kumar, T. M. S., & Kurian, C. P. (2023). Real-time data based thermal comfort prediction leading to temperature setpoint control. *Journal of Ambient Intelligence and Humanized Computing*, 14(9), 12049–60. <https://doi.org/10.1007/s12652-022-03754-8>
- Lala, B., & Hagishima, A. (2022). A review of thermal comfort in primary schools and future challenges in machine learning-based prediction for children. *Buildings*, 12(11), 2007. <https://doi.org/10.3390/buildings12112007>
- Liu, H., & Ma, E. (2023). An explainable evaluation model for building thermal comfort in China. *Buildings*, 13(12), 3107. <https://doi.org/10.3390/buildings13123107>
- Lu, S., Cui, M., Gao, B., Liu, J., Ni, J., Liu, J., & Zhou, S. (2024). A comparative analysis of machine learning algorithms in predicting the performance of a combined radiant floor and fan coil cooling system. *Buildings*, 14(6), 1659. <https://doi.org/10.3390/buildings14061659>
- Miao, S., Gangoellis, M., & Tejedor, B. (2023). Data-driven model for predicting indoor air quality and thermal comfort levels in naturally ventilated educational buildings using easily accessible data for schools. *Journal of Building Engineering*, 80, 108001. <https://doi.org/10.1016/j.jobe.2023.108001>
- Moshood, T. D., Nawanir, G., Lee, C. K., & Fauzi, M. A. (2024). Toward sustainability and resilience with Industry 4.0 and Industry 5.0. *Sustainable Futures*, 8, 100349. <https://doi.org/10.1016/j.sfsr.2024.100349>
- Mousavi, S., Gheibi, M., Wacławek, S., Smith, N. R., Hajiaghahi-Keshteli, M., & Behzadian, K. (2023). Low-energy residential building optimisation for energy and comfort enhancement in semi-arid climate conditions. *Energy Conversion and Management*, 291, 117264. <https://doi.org/10.1016/j.enconman.2023.117264>
- Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews*, 5(1), 210. <https://doi.org/10.1186/s13643-016-0384-4>
- Park, J., Kim, T., Kim, D., Alghimlas, F., AlRagom, F., Choi, H., & Cho, H. (2024). Field test of machine-learning based mean radiant temperature estimation methods for thermal comfort-integrated air-conditioning control improvement and energy savings. *Energy Reports*, 11, 5682–702. <https://doi.org/10.1016/j.egy.2024.05.040>
- Park, K. Y., & Woo, D. O. (2023). PMV dimension reduction utilizing feature selection method: Comparison study on machine learning models. *Energies*, 16(5), 2419. <https://doi.org/10.3390/en16052419>
- Pavirani, F., Gokhale, G., Claessens, B., & Develder, C. (2024). Demand response for residential building heating: Effective Monte Carlo Tree Search control based on physics-informed neural networks. *Energy and Buildings*, 311, 114161. <https://doi.org/10.1016/j.enbuild.2024.114161>
- Qavidel Fard, Z., Zomorodian, Z. S., & Korsavi, S. S. (2022). Application of machine learning in thermal comfort studies: A review of methods, performance and challenges. *Energy and Buildings*, 256, 111771. <https://doi.org/10.1016/j.enbuild.2021.111771>
- Sibyan, H., Svajlenka, J., Hermawan, H., Faqih, N., & Arizqi, A. N. (2022). Thermal comfort prediction accuracy with machine learning between regression analysis and naïve Bayes classifier. *Sustainability*, 14(23), 15663. <https://doi.org/10.3390/su142315663>
- Wolff, R. F., Moons, K. G. M., Riley, R. D., Whiting, P. F., Westwood, M., Collins, G. S., Reitsma, J. B., Kleijnen, J., & Mallett, S. (2019). PROBAST: A tool to

- assess the risk of bias and applicability of prediction model studies. *Annals of Internal Medicine*, 170(1), 51–8. <https://doi.org/10.7326/M18-1376>
- Xi, H., Wang, B., & Hou, W. (2024). Machine learning-based prediction of indoor thermal comfort in traditional Chinese dwellings: A case study of Hankou Lifan. *Case Studies in Thermal Engineering*, 61, 105048. <https://doi.org/10.1016/j.csite.2024.105048>
- Zhang, W., Wu, Y., & Calautit, J. K. (2022). A review on occupancy prediction through machine learning for enhancing energy efficiency, air quality and thermal comfort in the built environment. *Renewable and Sustainable Energy Reviews*, 167, 112704. <https://doi.org/10.1016/j.rser.2022.112704>
- Zhou, S. L., Shah, A. A., Leung, P. K., Zhu, X., & Liao, Q. (2023). A comprehensive review of the applications of machine learning for HVAC. *DeCarbon*, 2, 100023. <https://doi.org/10.1016/j.decarb.2023.100023>



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M G A R O N

Article

A synergistic teaching approach in interior architecture education: Plumbing system learning with augmented reality

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ABSTRACT

This study explores an innovative teaching methodology in interior design education incorporating Augmented Reality (AR) technology to create an immersive and interactive learning experience for building systems learning. AR transforms traditional didactic teaching into dynamic, 3D visualization, allowing students to explore and interact with technical/mechanical systems within the building in real-time. This approach also bridges the gap between theoretical knowledge and practical application, offering a deeper understanding of the intricacies of plumbing applications and their impact on interiors. In this context, interior architecture students taking the Environmental Systems Building Dynamic (ESBD) course were given a different practical experience in which AR technology has adapted through the drawing applications given in the course. It was observed that the students experienced the practice of plumbing knowledge through a digital and 3D practice compared to the classical method, and the effects of this experience process on the students' course and interior architecture practice were questioned through a survey. Considering the findings obtained, increasing students' theoretical knowledge of ESBD courses and their 3D practices have been evaluated through classroom-based experiments. Its impact on student engagement, comprehension, and problem-solving skills is questioned, shedding light on how AR technology could revolutionize the teaching of ESBD. Based on the student's experiences, suggestions are presented that this approach can be integrated into interior architecture education in different courses and can also be a guide in professional projects in the sector.

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INTRODUCTION

The traditional teachings of environmental building systems in interior architecture education have historically relied on conventional didactic methods and theoretical teaching.

Although these approaches are fundamental, they may need to meet the current needs of the time and provide students with a comprehensive and practical understanding of which plumbing is an integral part of sustainable interior architecture.

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This study addresses this gap by presenting an innovative pedagogical approach that utilizes the power of Augmented Reality (AR) technology. It has the potential to revolutionize the teaching of environmental building systems by providing students with dynamic, interactive, and immersive experiences in water plumbing. This approach bridges the gap between theory and practice, transforming the learning process into an engaging and multidimensional journey that allows students to explore, interact, and understand building systems in real time.

LITERATURE REVIEW

Building Systems in Interior Architecture Education

The course on Building (Service) Systems in Interior Architecture Education is a critical component within interior design departments worldwide. It provides students with a comprehensive understanding of the technical and mechanical aspects that underpin the creation of functional and sustainable interior spaces. To prepare students for the complexity of real-world design difficulties, this course aims to close the gap between theoretical understanding and practical application.

The curriculum is structured to align with industry standards and emerging trends, ensuring graduates are well-equipped for the dynamic field of interior design.

Building Systems courses in architecture and design education generally have essential topics such as historical evolution, environmental considerations, systems, installations, technology, regulatory compliance, practical applications, and professional practices. Under all these main topics, it is explicitly focused on building physics, mechanical, technical, electrical and acoustical systems, and sanitary systems such as water plumbing, heating, ventilation, air conditioning, cooling, lighting, electricity, fire, energy saving, architectural acoustics, etc (Echols & Ding, 1971; Binggeli, 2003; Oral, 2015; Sevinç et al., 2015).

Some accreditation bodies stated the course content of building physics courses in interior architecture education. The Council for Interior Design Accreditation (CIDA), a significant authority in interior architecture education, has a “Standard 14: Environmental Systems and Human Wellbeing” at CIDA Professional Standards 2024. According to this standard, interior architects practice the principles of acoustics, thermal comfort, indoor air quality, plumbing systems, and waste management regarding environmental impact and human well-being (CIDA, 2024). Moreover, The Interior Architecture/Design Education Policy (IFI) states the biases of interior design education in its policy; the environment topic is explained as “consideration for significant environmental factors, including sustainable development and the impact of climate change” at the standard of Interior Architecture/Design graduate's qualities

(IFI, 2020). The Interior Design Educators Council (IDEC), a collaborative council, defines the core values of interior design education in the organization's mission. It claims that ethics form the basis of interior design education, which also covers social, cultural, environmental, and international themes (IDEC, 2021).

Interior design students can effectively understand these systems if they consider building physics, components, construction, and interior details. Thus, practical applications become more important for this course. Also, interior designers should know building systems to complete the interior finishing and design details in professional life.

Yüksel scrutinized the courses on physical environment control for interior architecture education in Turkish Universities in his 2018 study. The course plans for the Interior Architecture Departments were examined in research conducted within the scope of 28 universities. The contents of these universities' mandatory courses, Environment, Physical Environmental Control, and Building Physics were investigated in terms of semesters, credits, and topics (Yüksel, 2018). A study on the environmental approaches that can be taught to students in interior architecture education is presented, and methods with suggestions on how and in what way environmental approaches can be included in undergraduate interior architecture education. In this context, the study also includes methods and suggestions developed for effectively using water under the components of building physics in interior architecture education and design processes (Adıgüzel Özbek, 2015).

Yılmaz and Eren examined student perspectives on digital and traditional drawing methods in environmental design studios of the landscape architecture department and the influence of these methods on academic performance in the course. Initially, a variance analysis was performed to identify if there was a disparity in student attitudes toward traditional and digital drawing techniques in the environmental design studio. The digital and traditional drawing techniques students acquired in the environmental design studio correlated with their academic accomplishments, and the difference between the groups was noteworthy (Eren & Yılmaz, 2022).

There has also been an investigation into how real-world design experiences and a problem-based learning methodology were applied to create educational materials in three-dimensional multi-user virtual environments (3D MUVEs). To help those who want to create these 3D MUVEs and use these environments for teaching, a design model was proposed. Students in the third year of the Department of Computer and Instructional Technology Education at a public university in Türkiye make up the study group (Doğan & Tüzün, 2022). In Iraq, a study investigated the degree to

which the prerequisites and directives of environmental education sanctioned by the National Architectural Accrediting Board (NAAB) are fulfilled in the academic curricula of the Architecture Department of Al-Nahrain University. The outcomes indicated that to comply with the NAAB stipulations on environmental education, there is a necessity to initiate applied practical facets of academic projects and the establishment of auxiliary laboratories for implementing the software and computations on such projects to validate the projects' performance from an environmental standpoint (Wahhab & Rizko, 2019). Some researchers examined the significance of Building Service Systems (BSS), especially how they should be contemplated during the initial architectural design stages. Course projects are utilized to underscore the importance of 3D digital modeling in revealing potential clashes and conflicts between BSS, specifically the plumbing systems on one side and between the design and those systems on the other. Additionally, a survey was conducted among students (Abdelhameed & Saputra, 2020).

Using AR Technology in Interior Architecture Education

The key feature that makes Augmented Reality (AR) suitable for architectural education is its ability to understand and transform information between the virtual and real world. AR can serve as a technical instrument within an architect's workspace. It allows viewing three dimensional (3D) drawings of a planned building, created with computer-aided design (CAD) programs, through a device with an AR mobile application (app). This provides the designer and user with a more realistic experience about various details, such as the facade appearance of the building, the materials to be used, and design feedback (Diao & Shih, 2019; Wang et al., 2013). Moreover, the architectural curriculum is directly linked to the real world, and it is critical to establish stronger connections with industry. AR could directly produce drawings of existing structures and virtual images of buildings on the construction site. AR accelerates the architectural work process and assists in the design phase and verification of the building (Balakrishna, 2013).

AR applications enable students to engage with a world of reality outside of the confines of traditional classroom instruction (Chen et al., 2011; Diao & Shih, 2019; Kamarainen et al., 2013). Besides, integrating digital technologies into educational processes is considered one of the difficulties encountered between students and teachers. However, students show great interest in these technologies. In educational institutions, there is an ongoing insistence on maintaining traditional strategies due to the fear of disrupting the field content due to the complexity of some computer applications. (Wang et al., 2013) Additionally, some studies have reported that the impact of AR technology on learning yields efficient results (Hsiao et al., 2010).

Another study highlighted the use of AR in architecture and construction education. AR technologies have proven beneficial in these fields in this study, but this app in higher education teaching and learning environments is still being explored (Hajirasouli & Banihashemi, 2022). A smartphone AR app that supports interior design educational activities was provided by another researcher. Students were able to learn about interior layout design and the implications of various design layout choices thanks to the program. Using their mobile devices, users were able to interact with 3D representations of virtual objects that were placed on top of a design layout plan (Chang et al., 2020). This article is another relevant research that discusses the role of AR in architecture education. The study includes the increased use of technology in education, particularly the rise of augmented reality. It focuses on how AR-based experiences are created and implemented in didactic activities within undergraduate architecture and urbanism courses. Also, it presents bibliometric analysis and quality assessment to highlight the benefits and challenges associated with incorporating AR in teaching AU, highlighting various approaches to its development and application. (Skubs & Cuperschmid, 2023).

These studies suggest that AR can enhance interior architecture education by providing a more interactive and immersive experience. However, more research is needed to fully understand AR's potential in this field and develop effective teaching methods that incorporate this technology.

METHODOLOGY

The case study was performed in Türkiye, with the Department of Interior Architecture and Environmental Design student participants in İstanbul Medipol University. During the Environmental Systems Building Dynamic (ESBD) course, students were given a plumbing practice in two different formats. Conventional and digital methods were questioned based on students' aspects and experiments. The case study was practiced in two stages. The first step is to create a framework and offer a quantitative benchmark based on research as a point of comparison for how easily interior architecture students can use instructional technologies (Vlachogianni & Tselios, 2022). Then, the attitudes of interior design students towards conventional and AR tools in ESBD courses were scrutinized. In the second stage, it is argued that a new system usability evaluation has an approach to contribute to this course and design education and development of the technological systems that are used in educational settings, and the impacts of AR tools over understanding plumbing systems were analyzed in System Usability Scale (SUS).

Research Questions

Very few studies in the literature of in-class applications for building physics and building systems are given in interior architecture education, explaining these applications through traditional and digital methods and measuring the differences between these several methods. Thus, the research is aimed to identify students' perspectives regarding the 3D modeling interface usability and the dominant aspect of plumbing drawing/design that they would use as future interior designers under three essential questions;

- Q1.** What are the attitudes of interior architecture students toward traditional and digital drawing tools provided in ESB D training?
- Q2.** How do the AR apps affect academic and sectoral success in ESB D courses?
- Q3.** Is there a relationship between the department's age, language, and level of education and the AR apps and convectional drawing method?

The course of ESB D

This compulsory course is provided in two semesters at the department. In the first semester, environmental, physical, environmental control, the evolution of building systems, city networks/distribution, sanitary systems, sewage systems, and heating systems were taught. The second semester includes HVAC, lighting, electrical, fire security, fire emergency, sprinkler system, and sound/architectural acoustics (Syllabus of ESB D, 2024). Drawing-based applications are more common in plumbing because the plumbing needs to be solved in detail at the intersection of interior finishing decisions and building structure. Thus, plumbing is a more critical system for interior students to understand building components and wet area design. In this course, students perform conventional drawing practices over AutoCAD-based plans. Two different programs just applied the case studies at their official course hours. In this course, some goals have been expected from students under the education outputs at the end of the year. These students learn installation solutions, relationships between buildings and installations, relationships between interior and wet area design, and 3D perception of building components and interior details.

Instruments

Three instruments were used in this research. The first gathers information about environmental systems, building systems, education processes, and drawing methods.

The second one is to develop a survey for a questionnaire using the Attitude Scale and System Usability Scale (SUS) with likert and open-ended questions. Attitude scales are used to understand students' perceptions and preferences towards different drawing techniques, design approaches

or educational methods. This scale is a tool including both positive and negative statements with five response options for respondents, from strongly agree to disagree strongly (Eren & Yilmaz, 2022). Also, Tarakci Eren et al. (2018) showed that these questions are reliable with Cronbach's Alpha test in their study. The SUS scale is used to evaluate the usability of design software or other technology-based tools. It quantifies and evaluates the usability of the digital interface for users. The SUS consists of ten statements under negative and positive attitudes. It consists of a ten-item questionnaire with five response options for respondents, from strongly agree to disagree strongly (Yong et al., 2020; Kandil et al., 2021; Vlachogianni & Tselios, 2022; Huang et al., 2023). However, its application in architecture/ design education does not seem to be a standard research topic. Eren & Yilmaz (2022), Tarakci Eren et al. (2018), and Yong et al. (2020) developed survey questions incorporating the SUS scale and the attitude scale to assess design students' perceptions regarding the utilization of the program in their studies related to the interplay between design courses and software usage. These studies demonstrate that the attitude scale and the SUS scale are effective tools for comprehending student impressions of various design methodologies in design education, assessing the usability of design software, and analyzing students' experiences. Both measures offer critical insights for enhancing design education, comprehending student experiences, and refining instructional resources.

The survey of this study was developed based on these studies. The questions were created under the titles of design education, professional life, personal development and contribution to students with relationships between these two drawing methods.

As a third instrument, a mobile AR app has been set up over a two-dimensional (2D) AutoCAD plumbing plan and shared with students to set up on their mobile phones. In the next step, students saw a 3D building structure model with a plumbing line holding their mobile phones over a 2D plan. Then, the survey was shared with students via Google Forms, and the first data was collected this way. Primary data analysis was performed using SPSS 21.0, which included internal reliability and validity tests and correlative analysis. In total, 35 questions were presented to students in a survey under demographic data, conventional drawing, and AR app practice.

Participants

The participants of this study included 121 undergraduate students of Interior Architecture and Environmental Design students at İstanbul Medipol University in Türkiye. 3rd and 4th year Turkish and English volunteer-based 121 students attended the ESB D courses in 2022. While there were sixty-nine attendees in the Turkish Program, there were fifty-two attendees in the English Program. The average age of the

participants in the study group is 21.75 years and 81.8% are women. In addition, 57% of the study group participates in the Turkish program. While 76% of the participants stated they were interested in computer and software technologies, 70.2% had never used any AR application. 65.3% of the participants have been in the construction site environment before.

AR app Setup in Interior Plumbing Practice

The AR application used in the study is a marker-based mobile augmented reality app. The application has been designed to work on Android-based smartphones and tablets. The Android platform is preferred because it is relatively common and is easier to adapt to app development kits with open-source codes. The two wet area plans with low flooring shown in Figure 1 were rendered three-dimensional using Autodesk 3D's Max program, and all the sanitary ware elements seen in the plan were added to the

relevant areas. The clean water and wastewater installations required by the sanitary ware elements in question were designed according to their technical specifications, coating materials were assigned, and then turned into a three-dimensional environment, as seen in Figure 1.

The next step is to develop the app on the Android platform. Unity platform was used to implement the three-dimensional model into an application. Unity is a real-time software development engine that designs apps and games for Windows, Mac, Android, iOS, and Linux platforms. Camera angles and light settings to be used during the display of the solid model in the Android application were added to the Unity engine as shown in Figure 2. Since the developed application has a pointer feature, a pointer image was added to the Unity platform. In augmented reality applications, the pointer is a method that allows the encoded properties of the model tracked by the mobile device's camera and associated with it to be displayed.

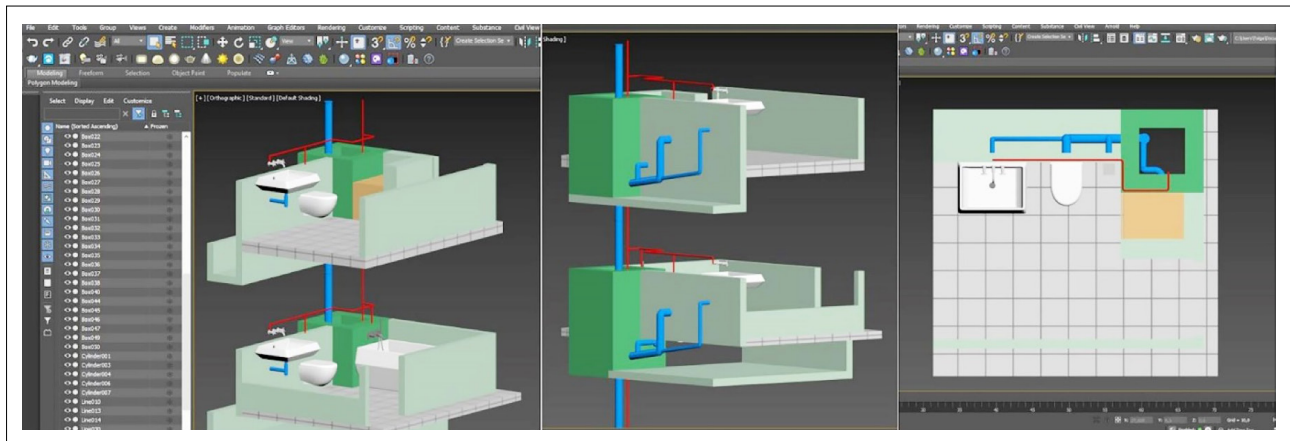


Figure 1. Modeling the plumbing system in 3D's max environment.

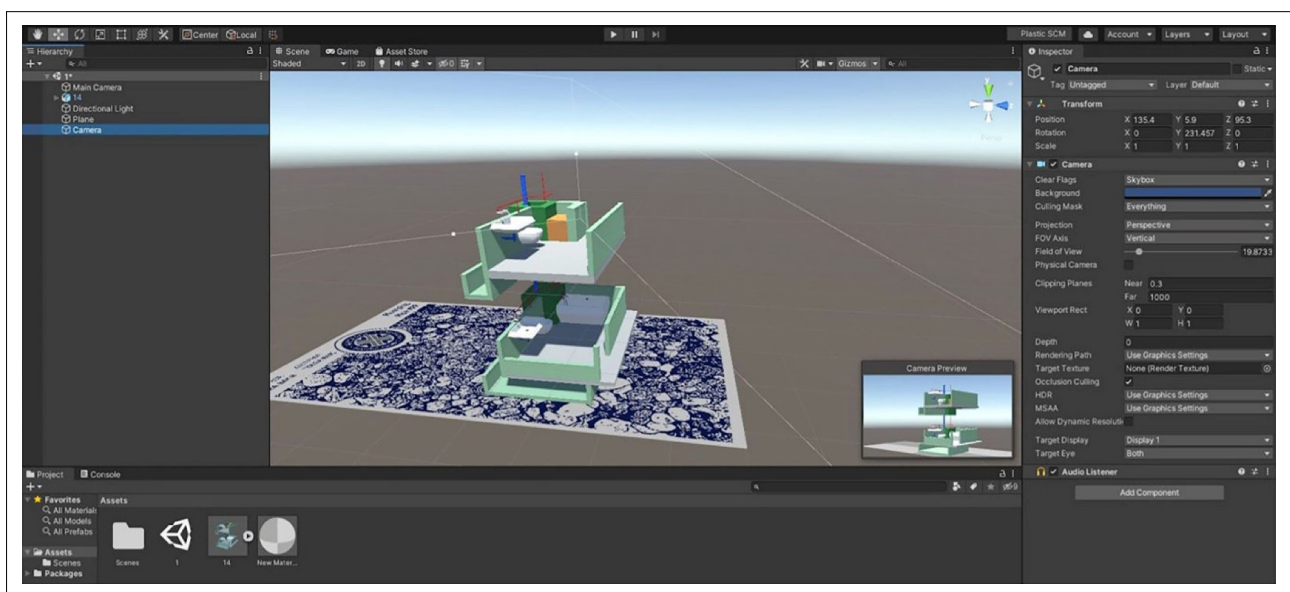


Figure 2. Building the application on the Unity platform.

Pointers facilitate the alignment of physical objects or spaces with the virtual environment and its components. In other words, the pointer transfers whatever digital information is defined in the computer environment to the physical environment.

The marker is connected to Unity software through a software development kit platform called Vuforia Engine. Vuforia Engine (Figure 3) is a programming interface (API) that provides real-time environmental viewing and interaction for mobile or glasses-based AR applications developed in Unity and similar engines. By adding the marker in Figure 4 to the online interface, a database was created. It is essential for the solid model of the mobile application to be displayed accurately in marker-based AR systems. The pointer must be designed to be identifiable by the camera of any Android mobile device.

The database created with Vuforia Engine is associated with Unity Editor in SDK format. The database marker is integrated with the 3D model in the Unity Editor. Following the required adjustments to ambiance, camera viewing angles, and the creation of license codes for the AR experience, the AR application was compiled into the ".apk" format and made available for installation on Android devices.

Students Practices' Experiments

Students experienced firstly conventional (CM), secondly Augmented Reality (ARM) methods and then gave feedback by comparing these two experiences during the lesson in the classroom.

Under the conventional method (CM) experience; students were firstly asked to solve the plumbing structure solution between the two floors, the wet volume apparatus specific to each floor, the relationship between shaft and whole pipes, clean water outlet, and wastewater drain elements in two-story wet areas with different layouts plans and draw them on the plan-section with CM in the plumbing practice. This

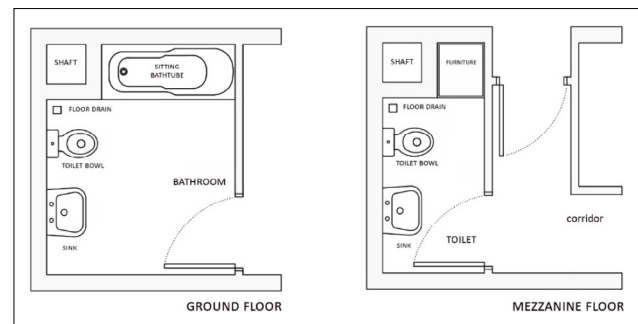


Figure 4. 2D Plumbing Plan on CM (hand drawing) practice.

included placing equipment, detailing the relationships between shafts and pipes, and showing clean and wastewater outlets. This aimed to evaluate their ability to understand and represent plumbing details in a 2D format. Students created hand drawings based on AutoCAD plans. (Figure 4)

Under the Augmented Reality App (ARM) experience, the students installed the 3D version of the plumbing practice created in the AR app on their Android phones. After opening the app, they viewed the plans in 3D by holding their phones over a pattern paper. (Figure 3) They observed the structural water installation solution between the two floors, the points where the clean and wastewater pipes pass in the building, and their relationship with the interior walls, floor, and plumbing chimney. This intended to develop their ability to perceive and understand plumbing systems in 3D. (Figure 5)

At the final step, they compared the 2D hand-drawn layouts (CM) with the 3D views of the placement of the apparatus and the wet area design criteria in the interior layout which they obtained through ARM. And then, they shared their feedback on their understanding and comprehension of the two methods via survey and class conversations. This comparison allowed for the evaluation of each method's strengths and weaknesses and their contribution to their

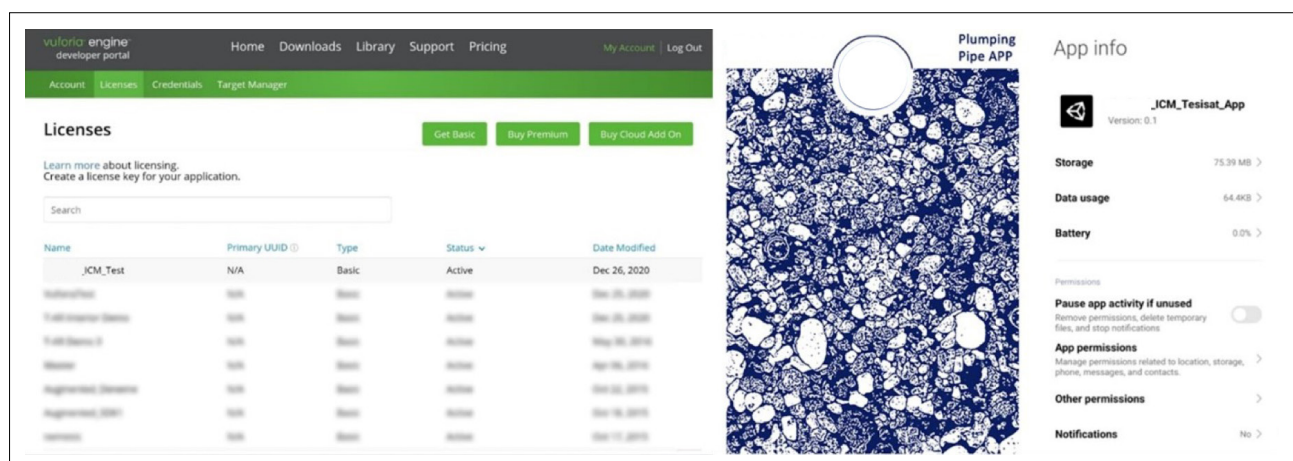


Figure 3. Vuforia Engine, AR marker, and interface of the application.

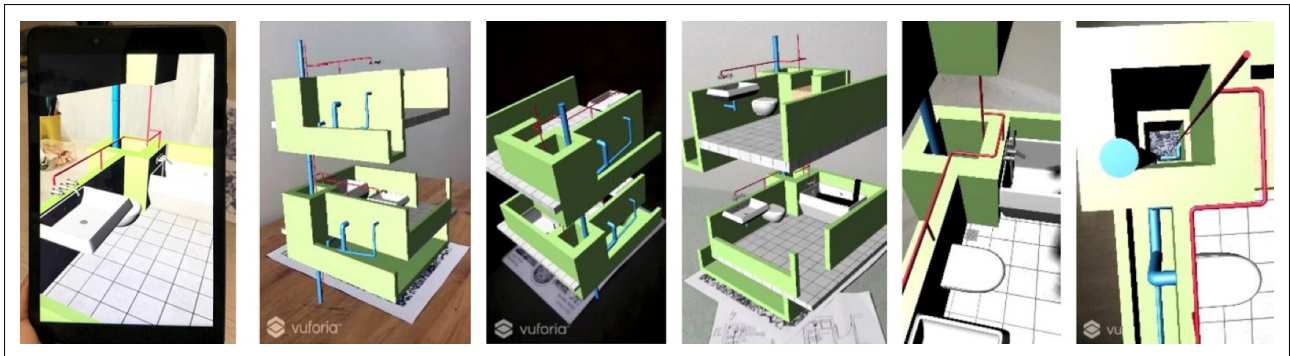


Figure 5. Phone and tablet screens of students during AR app practices.

learning. This facilitated a different perspective that allowed the students to compare the advantages and disadvantages of each method, understand the course content better and improve problem-solving skills. This experience also enabled students to determine the method that suited their learning styles best.

Data Collection and Analysis

During the research process, a scale was applied to the same group of students in which we could question the classical (hand) drawing method (CM) and augmented reality-based application method (ARM) processes together (Yong et al., 2020; Kandil et al., 2021; Vlachogianni & Tselios, 2022; Huang et al., 2023). This scale is commonly used because it is a consistent survey for assessing the AR system in education-based research across various practical disciplines. The questionnaire consists of 11 questions in which each answer is optionally ranked from "strongly disagree" (5) to "strongly agree" (1) based on the questions on the SUS scale (Kaya et al., 2019; Yong et al., 2020; Kandil et al., 2021; Vlachogianni & Tselios, 2022; Huang et al., 2023). The total score was calculated by summing the scores of the answers given on the scale. If a person answered "strongly agree" to every question, the score would be 55, while if he answered strongly disagree to all questions, the score would be 11. The score received by the participants is an indicator of the usability of the system. Participants were explained the purpose and stages of the study, were given written consent forms about the study, and were informed that they could withdraw from the study at any time. Identity information was hidden by assigning pseudonyms to the participants. The data in this study can only be accessed by the researchers. Values outside the normal range were omitted from the study. The study compared the application experiences of students in the CM and ARM practices, examining whether a meaningful relationship could be identified through demographic data. Additionally, feedback from students regarding the interior architecture education process associated with this course was gathered. In this context, some questions, such as demographic data, the relationship between CM and design

education/professional life relationship/contribution to personal development, and the AR practice's relationship to design education/professional life relationship/contribution to personal development, were asked to the participants regarding by also taking advantage of SUS scale.

Within the scope of the research, data were processed with SPSS 20.0, including normality, reliability, validity, and t-test analyses. In this process, Cronbach's alpha test was applied to determine the internal consistency of the responses. Cronbach states that the items in the scale with a high alpha coefficient are consistent with each other and consist of items measuring the same feature. The coefficient is expected to exceed 0.7 based on measurements.

In the measurements made, this coefficient was 0.842. Therefore, the measurement is reliable. A normality check determines the analysis method. To perform parametric tests, the data must be normally distributed. Kolmogorov-Smirnov test was applied to check normality. The reason for applying for this test is the size of the study group. For groups larger than 30, the Kolmogorov-Smirnov test is typically used. If the p-value exceeds 0.05, the data is considered normally distributed. As a result of the test, it was determined that this value was less than 0.05. Therefore, the data is not normally distributed. In cases where normal distribution does not occur, non-parametric tests are used. The Wilcoxon test assessed significant differences in the opinions of the same participants in the study group regarding two different situations. This test is used to evaluate the significance of the difference between the scores of two related measurement sets. Demographic information was analyzed using the Kruskal-Wallis H test and the Mann-Whitney U test applied to the variable status. The Kruskal-Wallis H test is a technique used to evaluate the significance of the difference between the means of three or more groups in groups that do not show normal distribution. The Mann-Whitney U test is used to test the significance between the averages of two groups. The mean rank and standard deviation were reported as descriptive statistics for the data obtained, with $p < 0.05$ considered as significant.

FINDINGS AND DISCUSSION

To determine whether there was a significant difference between the participants' total scores for the CM and ARM practices, the Wilcoxon sign-rank test was performed because the scores were not normally distributed. When Table 1 is examined, a significant difference was detected between the scores for CM and ARM in favor of AR scores ($Z=-3.071$; $p<0.05$). Accordingly, ARM ($MR=62.68$) applications are more effective than CM ($MR=44.08$). If the p -value is less than 05, it is considered that there is a significant difference between the two groups. So, there is a significant difference between the applications here. To determine the direction of the significant difference, the mean rank values are examined. The mean rank value indicates a preference for ARM.

The changes in CM and ARM, according to scales of the attitude and SUS, are shown in Table 2. This table shows the result of questions about the relationship between both

Table 1. Wilcoxon test results of CM and ARM practices

CM-ARM*	n	Mean Rank	Sum of Ranks	Z	p
Negative ranks	45	44.08	1983.50	-3.071	0.002
Positive ranks	64	62.68	4011.50		
Equal ranks	12				

* CM: Hand Drawing Practice Method; ARM: Augmented Reality Practice Method.

Table 2. Descriptive analysis of CM and ARM

Survey questions	CM		ARM	
	X	Standard Deviation	X	Standard Deviation
I find its use in the ESBD* course useful.	4.132	0.806	4.504	0.647
It increases the success of the ESBD course.	4.091	0.894	4.504	0.660
I think it makes learning the ESBD course easier.	4.182	0.827	4.603	0.555
I think it increases the interest in the ESBD course.	3.983	0.940	4.537	0.620
I need certain knowledge and skills to use in ESBD course.	3.620	0.887	3.661	1.084
I think it is a requirement specific to the course.	3.868	0.885	4.050	0.912
I think that this method, which I will use in the ESBD course, will also be useful in other courses.	3.959	0.860	4.397	0.701
I will need these practical methods, which I will in the ESBD course, in my professional life.	4.041	0.889	4.190	0.809
These practical methods that I will use in the ESBD course will provide advantages in my professional life.	4.132	0.774	4.364	0.683
These practical methods, which I will in the ESBD course, increase my interest in the profession.	3.711	0.970	4.140	0.934
These practical methods that I will use in ESBD course increase my self-confidence.	3.661	0.881	4.058	0.897

*ESBD: Environmental Systems Building Dynamic Course; CM: Hand Drawing Practice Method; ARM: Augmented Reality Practice Method.

two methods and design education, professional life, their contribution to personal development, their contribution to the student. In this table, the averages and standard deviations of the answers given by the participants to the questions as descriptive statistics regarding CM and AR applications are presented for each question. Mean values for an item vary between 1-5. It is seen that as it gets closer to 5, the average increases and the opinions become more positive. Table 2 also presents that the AR apps (ARM) have a higher mean score (X) for all questions asked. The results of the question "I need certain knowledge and skills to use in the ESBD course." showed that the averages for the item are close to each other. At this point, AR apps are easier to learn than CM practices. Regarding the question "I think it increases interest in the course.", it seems that AR apps are more interesting. Regarding the need and advantage of these methods in professional life, the opinion that both methods are necessary was seen with a slight difference (CM $X=4.041$; AR $X=4.190$). When examining the impact of applications on personal development, it was observed that the AR app showed effectiveness compared to CM.

Table 3 shows the results of the Mann Whitney U test conducted to analyze the differences in the augmented reality (AR) application (ARM) according to demographic characteristics. This analysis examines whether demographic characteristics of the participants, such as gender, program language, whether they came to the department willingly, interest in computer and software technologies, and previous experiences in the construction

Table 3. Mann Whitney U-Test results according to the demographic data status of ARM

Demographic data	Group	n	Mean Rank	Sum of Ranks	U	Z	p
Gender	Woman	99	59.02	5843.00	893.000	-1.321	0.186
	Men	22	69.91	1538.00			
Program Language	Turkish	69	69.99	4829.00	1174.000	-3.256	0.001
	English	52	49.08	2552.00			
I came to the department willingly.	Yes	114	61.58	7020.50	332.500	-0.741	0.459
	No	7	51.50	360.50			
I am interested in computer and software technologies.	Yes	92	63.36	5829.00	1505.500	-0.139	0.889
	No	29	53.52	1552.00			
I've been in a real construction site environment before.	Yes	79	57.45	4538.50	1378.500	-1.532	0.126
	No	42	67.68	2842.50			

ARM: Augmented Reality Practice Method.

environment, create a difference in their attitudes towards the AR application. There is no significant difference in the responses given to the AR application according to the gender variable ($Z=-1.321$; $p>0.05$). This shows that female and male students have similar views towards the AR application.

There is also no significant difference according to whether they came to the department willingly or not ($Z=0.741$; $p>0.05$). This result shows that the attitudes of students who chose the department willingly and those who did not are similar towards the AR application. There is also no significant difference according to their interest in computer and software technologies ($Z=-0.139$; $p>0.05$). This shows that students who are interested and not interested in technology have similar views towards the AR application. There is also no significant difference according to their previous experience in a real construction environment ($Z=-1.532$; $p>0.05$). This shows that students with and without construction experience show similar reactions to the AR application. There is a significant difference according to the program language ($Z=-3.256$; $p<0.05$). This difference shows that the attitudes of students in the Turkish program towards the AR application are significantly more positive than those of students in the English program. (Table 3)

Table 4 shows the responses of the question "I think that the CM/ARM that I will use in the ESBD course will also be useful in other courses". Using them in the design studios, detailed analysis in the interior, construction technology, and technical drawing courses would be more beneficial. While it comes to the fore that CM will be more useful in design courses, it is seen that AR app comes to the fore in courses that require detailed drawing/analysis. However, it has been determined that CM will be more beneficial for students in the construction technology course. Although this question is a Likert type, we expected detailed information about the courses from students' comments as an open-ended question. Outliers are extreme values that markedly deviate from other data points in the dataset and can influence the findings of the research. Such values can arise from errors in the data collection process, misunderstandings by participants, or unusual situations. Due to the inadequacy of the responses to open-ended questions, the results that were not significant in SPSS were not included in the table. The low usage rate of AR technology among participants indicates that more effort should be made to popularize this technology in education.

The frequency distribution of possible advantages (A) and disadvantages (D) of AR apps over plumbing practice in

Table 4. Descriptive statistics for the use of CM and ARM in other courses

I think that the method I will use in the ESBD course will be useful in other courses as well	CM		ARM	
	N	%	N	%
Design studio	88	41.90	77	37.56
Detail analysis in interior	59	28.10	62	30.24
Construction technology	40	19.05	39	19.02
Technical drawing	23	10.95	27	13.17

CM: Hand Drawing Practice Method; ARM: Augmented Reality Practice Method.

Table 5. Distribution of advantages and disadvantages of ARM

Advantage (A) / Disadvantage (D)		Frequency	%
(A)	3D perception	64	35.75
(A)	plumbing solution	20	11.17
(A)	relationship between structure and plumbing	33	18.44
(A)	relationship between space and wet area design	12	6.70
(A)	diameter dimensions and differences of clean/wastewater pipes are understood	16	8.94
(A)	it reduces learning time and provides ease of understanding	27	15.08
(D)	more interior details should be given	4	2.23
(D)	No paper should be needed to use the app	1	0.56
(D)	flexibility of movement / if there was something other than a phone	2	1.12

ARM: Augmented Reality Practice Method.

open-ended questions is presented in Table 5. Participants stated six advantages and three disadvantages of AR apps. When the table is examined, the most advantageous areas were 3D perception with 35.75%, followed by 18.44% understanding the structure-installation relationship and 15.08% reducing the learning time/easiness in understanding.

94.2% of the participants think that using this AR app will be advantageous in terms of course topics. However, some participants think that it has some disadvantages. They provided some suggestions for fixing current problems with the AR app. The application could be advantageous if more interior details are given, it can be used without paper, and it is supported with interventions such as flexibility of movement using an instrument other than the phone.

CONCLUSION

This study explored the use of Augmented Reality (AR) technology in interior plumbing drawing practices within the Environmental Systems Building Dynamic (ESBD) course in interior architecture education. The aim was to enhance students' 3D perception of building-indoor elements and the relationship between structure and installations, thereby improving the understandability of the applications. The study examined the "effect of integrating AR technology into 2D drawing applications on student participation, comprehension, and problem-solving skills". Two drawing methods-conventional technical drawing (CM) and AR-based experimental practice (ARM)-were compared. Students experienced the AR app on their mobile phones. Then, they had a questionnaire via Google Forms to evaluate the usability scores of mobile AR app on the Android system.

According to the survey, demographic factors such as gender, department preference, and previous construction site experience exhibited minimal impact on interest in

ARM. Turkish program students and individuals with prior construction experience exhibited greater engagement with AR ($Z=-3.256$; $p<0.05$).

Augmented reality demonstrated the highest effectiveness in "3D perception" at 35.5%, followed by "structure-plumbing relationships" at 18.44%, and "ease of understanding" at 15.04%. When comparing CM and ARM in the ESBD course, students rated ARM higher in design-education integration (CM: $MR=44.08$; ARM: $MR=62.68$). ARM has been shown to enhance learning and boost engagement in the course.

The open-ended responses indicated that the most beneficial aspect of the ARM was 3D perception, accounting for 35.75%. ARM was seen to provide high benefits in understanding the relationship between the structure and plumbing (18.44%) and reducing learning time and ease of understanding (15.08%). They stated that both CM and ARM methods are necessary for the ESBD (Environmental Systems Building Dynamic) course. They believe that the course should be supported by the ARM method as well as CM.

According to student experiences, through ARM, students gained a more detailed and relational understanding of plumbing systems. They particularly grasped the connections between structural water installations, the passage of pipes, and their interaction with interior elements. The 3D visualization offered by ARM helped students better perceive the complexities of the plumbing systems. This was significant, especially in understanding the relationship between space and wet area design. The opportunity to view the 2D CM drawings in 3D via ARM made the learning processes more effective. This allowed students to compare both methods and determine which suited their learning styles.

Moreover, it has been seen that ARM has the potential advantage over the other outcomes that are expected to be understood by students in this drawing practice, such as plumbing solutions, diameter dimensions, differences

between clean/wastewater pipes, and the relationship between space and wet area design. Although this method has significant advantages in terms of course outcomes, the AR apps should be improved in some respects, including the level of detail in a virtual 3D environment, using pattern paper, flexibility, and diversity of devices.

When the contribution of this study conducted within the scope of ESD courses to other courses is examined, it comes to the fore that CM would be more useful in designing essential courses. However, ARM comes to the fore in courses that require detailed drawing/analysis. CM proved to be especially useful in the "construction technology" course. The opinion was that the AR app would be useful in all courses requiring 3D perception, but it was also detected in open-ended questions that ARM should still be supported with CM.

Integrating AR technology into plumbing teaching aims to improve the education of interior architecture students and equip them with the knowledge and skills required to create environmentally friendly, water-efficient, and sustainable interiors. This research also contributes to innovative pedagogical methods in interior architecture education by emphasizing the transformative potential of technology in shaping the future of interior architecture drawing practices. In addition, the study also underlines the critical role of this technology in shaping the future of interior architecture education and the interior architecture industry.

This study emphasizes the transformative potential of augmented reality in influencing education and the interior architecture sector. Students recognized that both methods facilitate personal and professional development, with augmented reality exerting a more significant influence on confidence and sectoral preparedness. Both methods are necessary; however, AR is recognized as more beneficial for professional applications.

In the future, this study will continue to be applied to students of different programs and age groups. The current study's survey scale, app, virtual environment, and contents will be improved by enhancing the students' feedback and possible deficiencies they reported. The parameters that change or remain constant in students' attitudes towards in-class practices will be re-evaluated and investigated through these improvements in this course. Ways to increase students' interest and efficiency in this course will be continued with the aim of measuring students' future attitudes through in-class learning outcomes and developmental studies on adaptation to technology.

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REFERENCES

- Abdelhameed, W., & Saputra, W. (2020). Integration of building service systems in architectural design. *Journal of Information Technology in Construction*, 25, 109–22. <https://doi.org/10.36680/j.it-con.2020.007>
- Adıgüzel Özbek, D. (2015). The integrity of interior architecture education and environmental approach. In *Interior Architecture Education 3rd National Congress/Workshop, Theory and Practice Unity, Proceedings Book* (pp. 15–24). Istanbul Kültür University.
- Balakrishna, B. (2013). Augmented reality: This is the future call in. *The Master Builder*, June, 198–200.
- Binggeli, C. (2003). *Building systems for interior designers* (p. 3). John Wiley & Sons.
- Chang, Y. S., Hu, K. J., Chiang, C. W., & Lugmayr, A. (2020). Applying mobile augmented reality (AR) to teach interior design students in layout plans: Evaluation of learning effectiveness based on the ARCS model of learning motivation theory. *Sensors*, 20, 105. <https://doi.org/10.3390/s20010105>
- Chen, Y. C., Chi, H. L., & Kang, S. C. (2011). Use of tangible and augmented reality models in engineering graphics courses. *Journal of Professional Issues in Engineering Education and Practice*, 137(4), 267–76. [https://doi.org/10.1061/\(ASCE\)EI.1943-5541.0000078](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000078)
- Council for Interior Design Accreditation (CIDA). (2024). *Council for Interior Design Accreditation professional standards* (January 2024, pp. II–32). Retrieved on Sep 15, from <https://static1.squarespace.com/static/5c9ae7530490796e32442342/t/65a5980d-5a420b5eb172937e/1705351181383/Professional+Standards+2024.pdf>
- Diao, P. H., & Shih, N. J. (2019). Trends and research issues of augmented reality studies in architectural and civil engineering education: A review of academic journal publications. *Applied Science*, 9(9), 1840. <https://doi.org/10.3390/app9091840>
- Doğan, D., & Tüzün, H. (2022). Modeling of an instructional design process based on the problem based learning approach in three dimensional multi user virtual environments. *Education and Information Technologies*, 27, 6641–68. <https://doi.org/10.1007/s10639-021-10880-x>
- Echols, G., & Ding, D. (1971). Education for environmental systems design: Philosophy of the graduate program at VPI. *Journal of Architectural Ed-*

- ucation (1947–1974), 25(3), 77–82. <https://doi.org/10.2307/1423840>
- Eren, E. T., & Yilmaz, S. (2022). The student attitudes towards digital and conventional drawing methods in environmental design studios and the impact of these techniques on academic achievement in the course. *International Journal of Technology Design Education*, 32, 617–44. <https://doi.org/10.1007/s10798-020-09605-x>
- Hajirasouli, A., & Banihashemi, S. (2022). Augmented reality in architecture and construction education: State of the field and opportunities. *International Journal of Educational Technology in Higher Education*, 19, 39. <https://doi.org/10.1186/s41239-022-00343-9>
- Hsiao, K. F., Chen, N. S., & Huang, S. Y. (2010). Learning while exercising for science education in augmented reality among adolescents. *Interactive Learning Environments*, 20(4), 331–49. <https://doi.org/10.1080/10494820.2010.486682>
- Huang, Y., Hu, Y., Chan, U., Lai, P., Sun, Y., Dai, J., Cheng, X., & Yang, X. (2023). Student perceptions toward virtual reality training in dental implant education. *PeerJ*, 11, e14857. <https://doi.org/10.7717/peerj.14857>
- Interior Design Educators Council (IDEC). (2021). *The mission of the Interior Design Educators Council for interior design education, scholarship, and service*. Retrieved Sep 15, from <https://idec.org/mision-corevalues-visionstatements/>
- International Federation of Interior Architects / Designers (IFI). (2020). *IFI interior architecture/design education policy (IFI IA/D EP)*. Retrieved Sep 15, from https://ifiworld.org/wp-content/uploads/2022/02/IFI-Interiors-Education-Policy_IFI-IAD-EP-Sept2020.pdf
- Kamarainen, A. M., Metcalf, S., Grotzer, T., Browne, A., Mazzuca, D., Tutwiler, M. S., & Dede, C. (2013). EcoMOBILE: Integrating augmented reality and probe ware with environmental education field trips. *Computers and Education*, 68, 545–56. <https://doi.org/10.1016/j.compedu.2013.02.018>
- Kandil, A., Al-Jumaah, B., & Doush, I. A. (2021). Enhancing user experience of interior design mobile augmented reality applications. In *Proceedings of the 5th International Conference on Computer-Human Interaction Research and Applications (CHIRA 2021)* (pp. 101–08). <https://doi.org/10.5220/0010630400003060>
- Kaya, A., Öztürk, R., & Altın Gümüşsoy, Ç. (2019). Usability measurement of mobile applications with System Usability Scale (SUS). In *Industrial engineering in the big data era* (pp. 389–400). https://doi.org/10.1007/978-3-030-03317-0_32
- Oral, G. (2015). Building physics issues in interior architecture education in the context of integrated design approach. In *Proceedings Book of the 3rd National Congress of Interior Architecture Education/Workshop – Theory and Practice Association* (p. 15).
- Sevinç, Z., Çakır, O., & İlal, M. İ. (2015). Building physics courses in interior architecture education in Turkey. In *Proceedings Book of the 3rd National Congress of Interior Architecture Education/Workshop – Theory and Practice Association* (pp. 1–14).
- Skubs, D., & Cuperschmid, A. R. M. (2023). Role of augmented reality in architecture and urbanism education. *The Turkish Online Journal of Educational Technology*, 22(3), 71–87.
- Syllabus of ESBD. (2024). *The course in Environmental Systems Building Dynamics*. Istanbul Medipol University, Faculty of Fine Arts Design Architecture. Retrieved Sep 15, from https://mebis.medipol.edu.tr/ProgramBilgi/ProgramBilgileri?pBolumOID=W-C1bIfu15zand62aW18OzMox0Wt_ZDzwYM93fc-FuNJImc23RIF4RP8CnAr4I26ce&lang=tr
- Tarakçı Eren, E., Düzenli, T., & Akyol, D. (2018). Attitudes of landscape architecture students towards biomorphic and parametric design approaches in environmental design. *Anatolian University The Journal of Art and Design*, 8(1), 126–43. <https://doi.org/10.20488/sanattasarim.510285>
- Vlachogianni, P., & Tselios, N. (2022). Perceived usability evaluation of educational technology using the System Usability Scale (SUS): A systematic review. *Journal of Research on Technology in Education*, 54(3), 392–409. <https://doi.org/10.1080/15391523.2020.1867938>
- Yong, S. D., Kusumarini, Y., & Tedjokoesomo, P. E. D. (2020). Interior design students' perception for AutoCAD, SketchUp and Rhinoceros software usability. *IOP Conference Series Earth and Environmental Science*, 490, 012015. <https://doi.org/10.1088/1755-1315/490/1/012015>
- Yüksel, Ş. (2018). Physical environment control: Its importance and place in interior architecture education. *Urban Academy Urban Culture and Management Refereed Electronic Journal*, 11(1), 108–116..
- Wahhab, K. A., & Rizko, N. J. (2019). The importance of evaluating the environmental design and performance of student projects as a product of architecture departments: A case study. *Periodicals of Engineering and Natural Sciences*, 7(3), 1286–99. <https://doi.org/10.21533/pen.v7i3.666>
- Wang, X., Kim, M. J., Love, P. E. D., & Kang, S. C. (2013). Augmented reality in built environment: Classification and implications for future research. *Automation in Construction*, 32, 1–13. <https://doi.org/10.1016/j.autcon.2012.11.021>