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Physical vs virtual: A multi-layered perception experience on memory through historic buildings

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Abstract

This study investigates the layered relationship between memory and perception through the experience of historic buildings in both physical and virtual environments. Drawing upon theoretical foundations in memory studies and architectural history, the paper aims to explore how architectural elements, spatial perception, and sensory engagement contribute to individual and collective memory formation. The selected case study, Bostancı Primary School building in Istanbul, designed by Mimar (Architect) Kemalettin in the early 20th century, provides a historical context with its architectural and socio-cultural significance. The building has maintained its structural integrity and unique architectural characteristics for years and continues to be used as an educational building today, albeit with a different function. Therefore, it has a strong place in urban memory and provides a strong foundation for exploring the relationship between memory and space through in-situ observations and experiences as a part of daily urban life. The methodology involves a three-phase experiential framework incorporating physical experience (PE), virtual reality experience (VRE), and memory representation through photographs, screenshots, and sketches. Twenty senior architecture students participated in structured experiences within the real and virtual building environments. Data were collected through their drawing of route mapping, image capture, written expressions, and memory sketches. Then they were analysed using a dual thematic framework of Architectural References (AR) and Sensory References (SR), interpreted through episodic and semantic memory models. Findings show that while architectural references were more frequently recalled in both physical and virtual reality environments, VRE yielded higher rates of episodic memory activation due to its ability to eliminate physical barriers and enhance spatial comprehension. Conversely, PE experiences more strongly activated semantic memory, as the embodied tactile nature of physical space provided deeper sensory engagement. Additionally, sketch analyses revealed that participants predominantly recalled historical architectural features, with minimal reference to recent alterations, underscoring the dominance of collective memory imagery over present-day functions. This research contributes to the interdisciplinary discourse on memory and perception by proposing a comprehensive model that evaluates how historic buildings are perceived and remembered differently depending on the mode of experience. It also highlights the potential of virtual technologies in architecture by facilitating complex, layered memory engagements beyond physical constraints.

Keywords: historic buildings, memory, perception, physical experience, virtual reality experience

1. Introduction

Architecture is more than just creating visually appealing images. It establishes connections between individuals and their environment, while conveying the relationships and meanings that arise from these connections (Pallasmaa, 2007, pp. 11). The meanings do not exist concretely in buildings. They are formed during the experiences of spaces by individuals, who perceive them not as mere collections of visual images but as fully embodied material and mental presences

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(Pallasmaa, 2007, pp. 44). Although this experience may initially focus on the sense of sight, as architectural works present pleasingly shaped and moulded surfaces (Pallasmaa, 2007, pp. 12), architecture engages all senses simultaneously. The physical space perceived through the integration of all senses gains meaning in the mind by associating images with experiences. What makes this mental formation possible is the memory.

Memory refers to acquiring, processing, storing, and later recalling information related to the built, natural, and social environment (MEMO, n.d.). Therefore, it is a subject of various disciplines, such as neurology, sociology, psychology, history, literature, and architecture, etc. In architecture, the studies primarily focus on urban memory, in which the city is considered a "collection of objects and practices that enable recollections of the past and that embody the past through traces of the city's sequential building and rebuilding." (Crinson, 2005, pp. xii). In this anthropomorphist concept, "a city remembers through its buildings, so the preservation of old buildings is analogous with the preservation of memories in the human mind." (Crinson, 2005, pp. xii). Urban and architectural memory is created by the physical transmission of architectural artefacts, especially through the historic buildings, from one generation to another. However, architecture and space are not isolated creations; in addition to their materiality, they also have conceptual content (Pallasmaa, 2007, pp. 41-44). This content emerges by recalling the memories on spaces through specific events, general knowledge, and facts accumulated over time, regardless of whether they have been experienced by individuals in the past.

The social environment is crucial in forming individual memory (Assmann, 1997, pp. 39). While societies do not possess a memory of their own, they significantly influence the memories of individuals. Individuals remember what they have personally experienced and the events and facts recounted and attributed meaning by others. This recollection occurs within a semantic context (Assmann, 1997, pp. 40). However, knowledge of human activities from an inexperienced past can be acquired by tracing the concrete remnants they left behind (Connerton, 1999, pp. 25). The more memory is related to unexperienced past and facts, the more it needs concrete traces that are perceptible signs of a fact no longer directly accessible (Nora, 2006, pp. 25; Connerton, 1999, pp. 25). These traces -such as a ruin, a narrative, an inscription, or a historic building- place the memory at the centre of the history as well as architectural history. In this context, architecture is not just a physical entity but a powerful tool in constructing memory, as it provides concrete and abstract links to the past.

In this memory construction, where memory has transformed into a need for history (Nora, 2006, pp. 24), architecture is used in its most concrete and abstract forms because memory emerges with people, time, and space. Historic buildings, in particular, play a significant role in this process, as they serve as physical and societal manifestations of the past, shaping the urban memory. These historic buildings, which are also included as architectural heritage, refer to buildings and/or building groups that reflect and -moreover, embody- the values of the cultural environment in which they exist, which need to be transferred to the future with their unique qualities.

Within this theoretical framework, the paper aims to uncover the relationship between memory and individuals' perception processes and patterns through their experiences in historic buildings. The significance of this study lies in its exploration of how historic buildings are not merely the physical collections of urban memory but also contain references to the multi-component nature of memory as the accumulation of knowledge and culture of the past. Within the scope of the research, the experiences of the Bostancı Primary School building, built by Mimar (Architect) Kemalettin in Istanbul in the early 20th century, in different environments are discussed.

The building was chosen as a case study not only for its stylistic characteristics and its architect but also due to its significance within the realms of architectural, urban, and collective memory. Primarily, the sustained preservation of Bostancı Primary School's original function as an educational building and structural integrity over years has contributed to its profound imprint on

urban memory. Furthermore, its current use -albeit under a different function, yet still within the educational facility- provides a strong foundation for exploring the relationship between memory and space through in-situ observations and user experiences. This framework simultaneously enhances the methodological applicability of the study and facilitates systematic data collection.

Buildings like Bostancı Primary School, whose function has changed but which are still a part of urban life, are experienced physically, but the mind and heart remember them through the arrangement, modification, distortion, or erasure of previous experiences (Bastéa, 2004). In this act of remembering, the perception that shapes the experience cannot occur independently of the memories. The source of perception and the recollection of past experiences in memory collaborate to create the experience (Bergson, 2015; Squire, 1987). Memories interconnect them and carry the past into the present in the individuals' minds (Deleuze, 2006). This experience can be a direct physical one with on-site visits to the building, or today, it can be realised as a virtual experience (VRE) through digital technologies and environments (Figure 1).

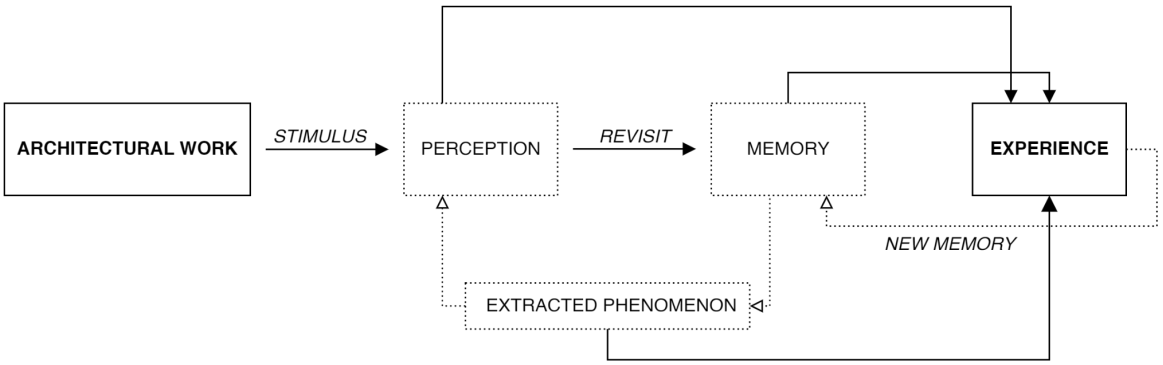


Figure 1 Relation of perception, memory and experience

Technological advances offer various ways to represent historic buildings, serving to preserve, reconstruct and conserve these cultural assets. Digital technologies also enable new possibilities for the sustainability of historical traces by integrating digital content and virtual layers into architectural artefacts. This is based on using computer-based technologies to document, preserve or recreate these artefacts with outstanding historical, aesthetic and cultural values. It also aims to offer digital experiences to a global audience, transcending time and space. Historic buildings bridge the gap between the past and future, representing a diversity of intercultural values including "symbolic, historic, artistic, aesthetic, ethnological or anthropological, scientific and social significance" (UNESCO,2009). Relationships established with historic buildings play an essential role in forming the collective memory of the past and the present. Therefore, studies on historic buildings today should have a multidisciplinary perspective and scope encompassing digital and historical methodologies.

In this manner, this paper presents a more comprehensive understanding of the perception and memorability of a historic building -Bostancı Primary School- in real-life and virtual reality environments. The study employs a three-phase experiential methodology to examine how memory and perception operate in physical and virtual experiences of a historic building, -Bostancı Primary School building. The research consists of a physical experience of the building (PE), a virtual reality experience of the building (VRE), and memory representations of these experiences through sketches, photographs, and verbal expressions. Data were collected from 20 senior architecture students through route mapping, image capturing, and memory sketching.

Thematic analysis was conducted using a dual-coding framework that classified participant responses into Architectural References (AR) and Sensory References (SR). To further explore the relational structures and saliency of these codes, the data were modeled using Graph Commons, a network mapping platform suitable for visualizing qualitative patterns through node-link structures. This visual-relational mapping was then supported by quantitative analysis. The

weighted frequencies of each subcategory -AR: elements, AR: spaces, SR: interventions, and SR: materials- were aggregated and compared between two different experiences using the Wilcoxon signed-rank test which is suitable for small sample sizes and ordinal or non-normally distributed data. This two-step analysing approach combined qualitative pattern detection and quantitative statistical validation, yielding a comprehensive framework for assessing how architectural memory is shaped across physical and virtual environments.

The holistic approach of the study will develop a vision-based perception of space and enable the discovery of a comprehensive experience by integrating qualitative and quantitative features. Among all, it is believed that this research at the intersection of digitalisation and architectural history will not only establish a framework questioning the transformative impact of memory, perception, and experience but also ensure a widespread base for the digitisation of a historic building, and the dissemination of a layered perception of architectural history.

2. The Architectural Features of Bostancı Primary School Building

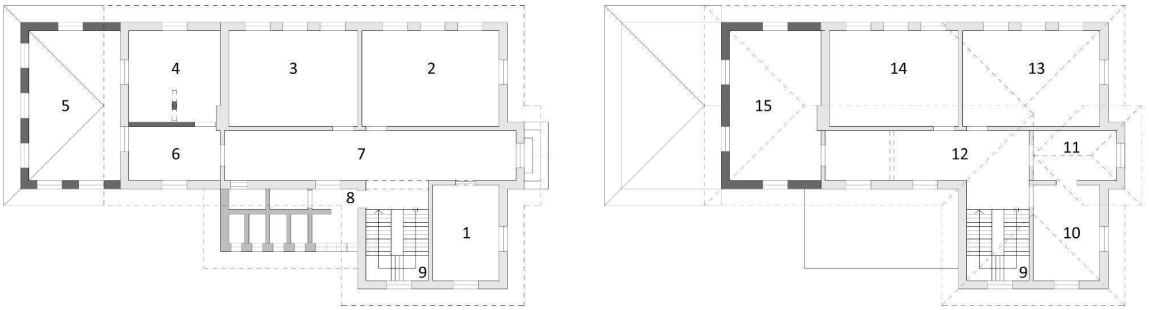
The school building, named initially İbrahim Paşa or Abdülhamid I Mekteb-i İptidaisi (Primary School), was a unique creation of Kemalettin, designed in conjunction with the Kuloğlu Mosque nearby. The exact construction date is a matter of debate, with some studies dating it to 1913 (Yavuz, 1995, pp. 127) and others to 1914 (Göktürk, 1963; pp. 3001-3002). However, an article from 1913, which reported that education at the school had commenced four months before its publication, suggests a construction date of 1913 (Yavuz, 2009, pp. 215). Today, the building serves as Halk Eğitim Merkezi (Community Center).

Kemalettin's architecture is a theoretical integration of the traditional Ottoman world with the Western world, both of which he experienced during his engineering education at Hendese-i Mülkiye Mektebi (Engineering School) and his studies of architecture in Germany, at the last decade of the 19th century. It emerged as a reflection of modernisation efforts of the Ottomans, primarily aimed to combine the classical elements with modern techniques and materials as an architectural counterpart of the socio-cultural transformations at the turn of the century. It is embodied through the socio-cultural and ideological perspectives of late Ottoman dynamics and incorporates stylistic references to previous eras' architectures, with tiles, wide eaves, domes, and pointed arches (Bozdoğan, 2001, pp. 16).

However, Kemalettin's architecture has a modern approach, aiming to develop an architectural idea with a particular linguistic unity, as well as the buildings' functions and spatial organisation, and how the spaces were used. Although he designed and built many buildings in Ottoman territory, educational buildings are the most prominent ones. The efforts to modernise the traditional education system since the late 19th century physically required new typology of educational buildings, which provided a foundation for Kemalettin to realise his ideas. These buildings architecturally employ new construction techniques and materials for contemporary functions with spatial design. Therefore, the Bostancı Primary School building, which still maintains its structural integrity today and continues to serve public functions despite changes in its original function, continues to exist as concrete traces of past activities that have not been experienced or perceived by the senses.

The school building had an L-shaped plan on two floors (Yavuz, 1995, pp. 127; Yavuz, 2009, pp. 215). The entrance on the short side is accessed with several steps, approximately half a floor in height (Yavuz, 2009, pp. 81). In the building (Figure 2), there was one room on the left side of the main entrance (no. 1) and two rooms on the right side of the hallway (no. 2 and no. 3) on the ground floor. Directly opposite the main entrance is a single-story, pitched-roofed large space at the end of the hallway. Later, it was divided into a secondary corridor (no. 6) and a room with an additional wall and structural column (no. 4). The toilets in the single-story addition next to the stairs on the ground floor (no. 8) are not included in the original drawings, and it is unknown whether they were added during the construction or a later repair. A new large single-story space (no. 5) with a pitched roof has been added at the end of the hallway, facing the entrance. The back door leading to the

courtyard directly here is now closed. In the original building, the upper floor plan is the same as the ground floor, consisting of a room on the left side of the hallway (no. 10) and two rooms on the right (no. 13 and no. 14). In a later repair, a space was added to the upper floor of the large single-story area (no. 15). The hallway (no. 12) above the entrance has been partitioned by a wall, transforming it into a closed space, a room (no. 11). Thus, over the years since its construction, the original building has been continuously expanded with additions according to needs, taking on its present form.



Ground Floor: Office (1), Library (2), classroom (3 and 4), atelier (5), open office (6), corridor (7), wc and kitchenette (8), staircase (9); Upper Floor: corridor (12), office (10 and 11), classroom (13 and 15), office -manager room (14).

Figure 2 Floor plans of the current state of the building (Bold parts are later additions)

On the symmetrical front facade (Figure 3), the entrance is extended outwards, rising throughout the entire building height and surpassing the roof level (Yavuz, 1995, pp. 127; Yavuz, 2009, pp. 81). Thus, the main entrance axis of the building was highlighted, as in Kemalettin's other school buildings. The building has brick masonry walls covered with a tiled, pitched wooden roof and wide eaves (Yavuz, 2009, pp. 81-215). On all grouted and mortared facades to give the impression of masonry, there are rows of windows with pointed arches on the ground floor and rectangular lintels on the upper floor (Yavuz, 1995, pp. 127; Yavuz, 2009, pp. 81-215). In the original building, these window rows were in groups of three but were individual in later additions. On the facades, the floors are marked with horizontal mouldings. The mouldings following the pointed arches on the windows on the ground floor are connected at the level of lintels, creating a continuous band around the entire building (Yavuz, 1995, pp. 127; Yavuz, 2009, pp. 81-215). These features, typical to the Ottoman architecture, contribute to the building's unique aesthetic and historical significance.

Figure 3 The facades of the building

Bostancı Primary School building holds a significant place in history due to its unique combination of structural and conceptual aspects, making it a notable representation of the educational buildings designed during this period. It has managed to preserve both its structural and architectural integrity, largely maintaining its originality, and exist in harmony with the

environment. Furthermore, its relationship with an important person -Mimar (Architect) Kemalettin-, and an institution also attributes the building more remarkable historical significance in urban memory. The building also holds documentary value regarding the socio-cultural aspects of its era, as well as technical knowledge, skills, materials, and craftsmanship. Even though the building is re-functioned with changing social patterns, the continuity of its usage increases its significance by preventing it from belonging to a specific period historically.

3. Perceptive Memory Framework on Historical Building Experiences: Bostancı Primary School

Despite its close connection with the past, memory is a present action (Nora, 2006, pp. 19). It is a deeply personal process, where facts are stored in memory only after they have been experienced, perceived, and mentally operated by individuals. It involves the merging of concepts and images, making them inseparable (Assman, 1997, pp. 42). This union of concepts activates memory by attributing semantic content to experiences based on senses, further emphasising the personal nature of memory processing.

In architectural literature, the concept of memory is often viewed as an accumulation created by the physical presence of buildings. However, this research takes a different path. It considers "the succession of events as constituting a city's memory, providing a unique psychological context for understanding the city." (Crinson, 2005, pp. xiii). This departure from existing methods and incorporating a broader, multidisciplinary perspective that includes psychological aspects is a step in terms of architecture.

In memory studies, the initial classifications are based on short-term and long-term memory (James, 2007; Radvansky, 2011). Short-term memory is where information is temporarily stored before being transferred to long-term memory and where the information stored at once is limited. Long-term memory, however, enables storing information that a person has acquired, learned and experienced throughout life. The first classifications of long-term memory were declarative and procedural memory (Figure 4). This classification was expanded in subsequent studies to include procedural, perceptual representation, semantic, primary, and episodic memories (Schacter & Tulving, 1994). Since procedural memory lacks a consciously controlled structure and its output is non-cognitive (Schacter & Tulving, 1994), the research focuses on declarative memory and its subtypes shaped by cognitive perceptions. In this manner, declarative memory, where conscious remembering is possible, contains information about experienced events or general knowledge and facts. It has two subtypes: (1) episodic memory which includes memories and events, and (2) semantic memory which includes semantic and factual data.

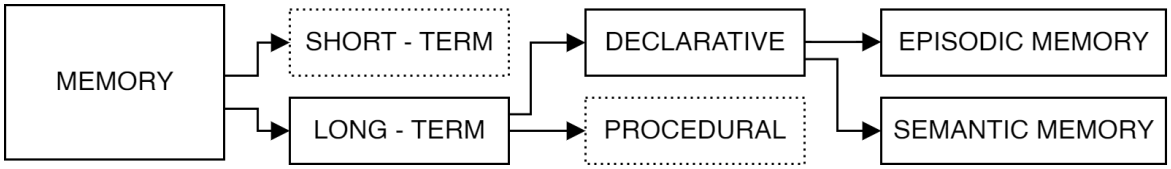


Figure 4 Memory types within the scope of the study

Episodic memory enables storing and recalling experienced events by establishing a relationship with time and space. The reproduced, subjective and spontaneous knowledge of the past includes time and spatial information (Broad, 1925; Brewer & Pani, 1983). However, semantic memory is where general information, facts, definitions, and meanings are stored without being associated with time or space. It is the conscious, objective and spontaneous knowledge of the past, including time and spatial information (Broad, 1925; Brewer & Pani, 1983). In this context, the paper intends to discover how perception transforms architectural experience by working as a memory filter through historic buildings, how this layered reading, created in physical perception, would differ when experienced virtually, and how perception processes transform in different environments. The framework is based on various layers created to explore this dynamic and dialectical process of episodic and semantic perception.

Understanding the complex relationship between these layers necessitates the inclusion of individual memory data for a more comprehensive perspective rather than a linear reading of history. In the theory of architectural history, the dynamic and dialectical context is often presented through a historical montage rather than a linear reading (Coles, 1999). The relationship between past and present is temporal, iconic, and dialectical, replacing the metaphors in discourse with ones akin to memory, perception, and experience. Historical knowledge no longer seeks to retell the sequence of events but compresses them into a dense iconic simultaneity while semantically intertwining them (Benjamin, 2016). Therefore, to enable a multi-layered and dialectical reading of a historic building in the context of episodic and semantic memory, a three-stage experience (Figure 5) has been created based on different layers of experience, perception, and memory, embodying them with various representations.

The experience was carried out with the voluntary participation of 20 architecture students who were carefully selected from the 4th-year grades because of their more comprehensive knowledge of architecture. All the students, aged between 22 and 25, had resided in Istanbul for at least four years and as a result of their academic coursework and daily experiences, they possessed detailed knowledge of historical buildings and could readily recall information related to the architectural features of Bostancı Primary School. Most of them had prior exposure to virtual reality technologies through their coursework or personal interest. Approximately 85% had used VR at least once before. All participants had foundational training in freehand drawing and experience with digital design tools. While this demographic provides consistency in architectural knowledge, it also limits generalizability beyond this population (Mikropoulos & Natsis, 2011).

Firstly, as a preliminary phase, a short seminar session was held by the researchers on the socio-cultural aspects and the architectural features of the period in which the building was designed, as well as the architectural approaches and designs of the leading Ottoman architects. This session aimed to activate short-term memory by having participants recall information they learned in the previous years of their architectural education on late Ottoman architecture and architectural history. Since many of the buildings built during this period still exist in Istanbul, the city where the participants live, and are actively used in daily life, the participants are already familiar with the architecture of this period. With the seminar, their awareness that the architecture of this period is not excluded from today's urban life and architecture was increased. However, Bostancı Primary School was excluded from the scope of this seminar so that it was not directly decisive in memory during experience.

Experience (Mapping with the walking route and stopping points): Subsequently, a visit to Bostancı Primary School, both physical (first phase) and virtual (second phase) was arranged. In order to allow each participant to perceive the building in its unique form, free from the influence of others, these visits were conducted individually under the supervision of the researchers. Thus, in order to enrich the research experience, the diversity of perceptual differences that the effects of spatial experience on memory and recall will cause among individuals were also included in the research.

A study based on on-site observation and experience was conducted in the building for physical experience (PE). During this physical experience, each participant was taken into the building one by one under the supervision of the researchers and wandered freely individually for 15-20 minutes. Moreover, the building was modelled in 3D with all its details and features, and a study was carried out based on observation and experience in the virtual reality experience (VRE). The virtual reality experience was conducted by participants' own computers in an indoor setting. Each participant individually navigated the virtual environment for 15-20 minutes, without external guidance, to maintain experiential authenticity. The VR model was developed using detailed 3D scans and architectural modeling software, ensuring spatial accuracy. The freedom to explore without physical constraints enabled a more holistic perception of spatial configurations. This aligns with

current research suggesting that embodied spatial interaction in immersive VR environments enhances episodic memory retention (Slater & Wilbur, 1997).

While the participants were physically and virtually experiencing the building, they were given pre-prepared leaflets and asked to mark the routes on the floor plans of the building they followed and the stopping points on this route. The leaflets included drawings of the building's original floor plans, in particular; thus, it was questioned whether the participants would notice the latter added spaces or changes in the building.

Perception (Photographing selectively and consciously): Participants were assigned to take ten photographs during the PE and ten screenshots during the VRE that attracted their attention or impressed them and mark their exact points on the floor plans of the building.

Memory (Making sketches based on remembering): As drawing activates embodied cognition and spatial recall, providing a bridge between perception and memory (Pallasmaa, 2007), after experiencing the building physically and virtually, they verbally expressed why they took photographs and screenshots and drew four sketches of what they remembered. All memory sketches were completed within 15 minutes after each experience session to capture impressions while memory was still fresh. This timing was consistent for both physical and virtual experiences, which is considered crucial in capturing vivid episodic recall (Epstein & Vass, 2014).

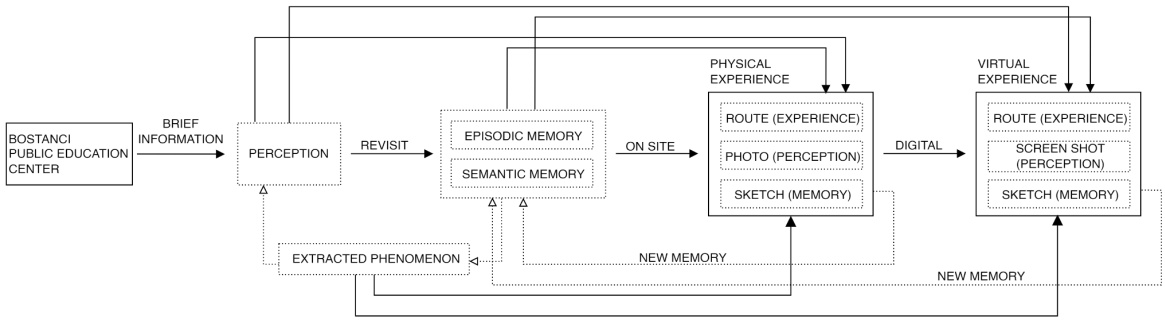


Figure 5 Framework of the experiences

In light of the diverse participant experiences and the variety of outputs collected, a concept-driven analytical approach was employed to identify both episodic and semantic parameters, categorized under two main themes: *architectural references (AR)* and *sensory references (SR).* This dual framework was designed to capture both the objective and subjective dimensions of memory. Through a detailed content analysis of photographs, screenshots, sketches, drawings and textual narratives of the participants, subcategories began to emerge, focusing on *spaces*, *materials*, *architectural elements*, and *interventions*.

To further explore the interrelations between these categories, a relational matrix was constructed. This matrix enabled the systematic categorization of all representational forms, mapping each data point under the broader headings of architectural references and sensory elements, and subsequently organizing them within the aforementioned subcategories. These representations of the participants include *arched window rows*, *staircases*, and *landings*, which are classified as *architectural elements*; *spatial integrity*, *additions*, and *spatial perception*, categorized under *spaces*; *columns*, *decorative objects*, and *furnishings* as *interventions*; and materials such as *wood* and *marble*. However, determining whether a particular item belongs to the domain of architectural references or sensory references necessitates a more nuanced and interpretive analysis.

A holistic examination of participant representations -particularly through semantic analysis of textual expressions- revealed that individual concepts often span multiple categories. For example, *arched window rows* may be associated with both *architectural references -element*, *sensory references -element*, and *sensory references -intervention*. Likewise, the concept of a *wooden staircase* may be interpreted within the contexts of *architectural references* as an *element*,

architectural references as a *material*, or *sensory references* as a *material*. Similarly, when a drawing and accompanying narrative emphasize *natural light*, the focus may be situated within the *sensory references as spatial* category. The term *room entrance*, depending on the context, can be interpreted either as an architectural element or as a spatial feature.

To deepen the analysis, the study utilizes Graph Commons, a collaborative platform for data mapping and network analysis. This tool enables a sequential examination of parameters through the application of centrality analysis, which helps to sort and identify key nodes within the network. By employing PageRank centrality measures, the most influential parameters in the system are identified. Each code served as a node, while co-occurrences or narrative linkages within individual responses formed the edges. Node centrality and influence were quantified using PageRank algorithms, enabling identification of dominant architectural and sensory elements in participants' memory formation (Brandes & Erlebach, 2005). Additionally, the mappings are interpreted through density zones, defined by the spatial coordinates of the participants' data. Combined with centrality metrics, this spatial analysis offers a comprehensive view of the collective perceptual memory experience.

3.1. Experience 1: Stopping Points of the PE

It is noteworthy that stopping points of the PE accumulate in specific areas (Figure 6). Especially on the ground floor, they spread towards the interiors; however, on the upper floor, they are focused on the entrance areas of the rooms (R). This is related to various new decorative objects in the ground floor hallway (referring to interventions as SR), preventing the holistic perception of the space. The primary stopping point is the central intersection zone on the hallway (Figures 7A & 7B), where the entrances of R2 & R3 (spaces as AR) (Figure 7C) and the staircase (elements as AR) (Figures 8A & 8B) are met. It was decisive that the spatial integrity of rooms (spaces as AR) was perceptible and that the arched window rows (elements as AR) were clearly visible from the room entrances. This intersection, the brightest point of the hallway (elements as SR) due to the natural light from the windows on the wall in the stairwell, also defines a point where the original wooden staircase (elements as AR and materials as SR) is perceived entirely. On the wall surrounding the hallway, there are original arched windows (interventions as SR) that were closed and lost their function due to the latter added toilets (spaces as AR) (Figure 7D).

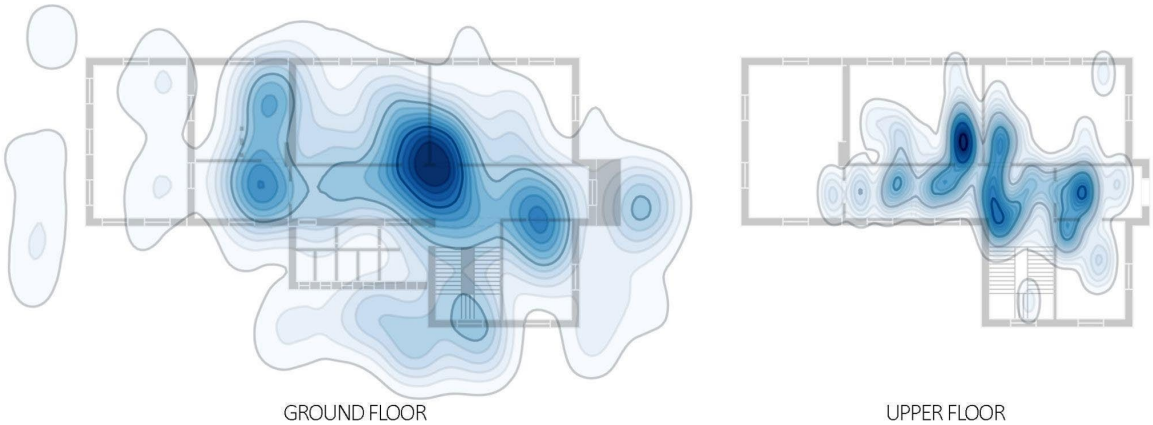


Figure 6 Stopping points of the PE

The secondary stopping points in R4 & R6 (Figures 7E & 7F) seem to be related to changes in the building over time, such as the structural column (interventions as SR), which is a later addition and not present in any of the other rooms, and the lower ceiling height (spaces as SR). While the furnishings (interventions as SR) do not allow easy circulation within R5 (Figures 7G & 7H), the stopping points can be described as the points where the arched door (elements as AR), located between the original arched window rows but closed today (interventions as SR), can be perceived as a whole. However, to a small extent, the others accumulated in the entrance area of R1, which

is on the left side of the main entrance. This is related to the bordering wall (elements as AR) at the right side of the main entrance (spaces as AR), and the entrance to R1 (elements as AR) is the first one inside the building. The density of stopping points in the staircase landing (elements as AR) is associated with the windows (elements as SR), that allow the silhouette of the mosque built next to the school building to be seen and perceived from the inside.

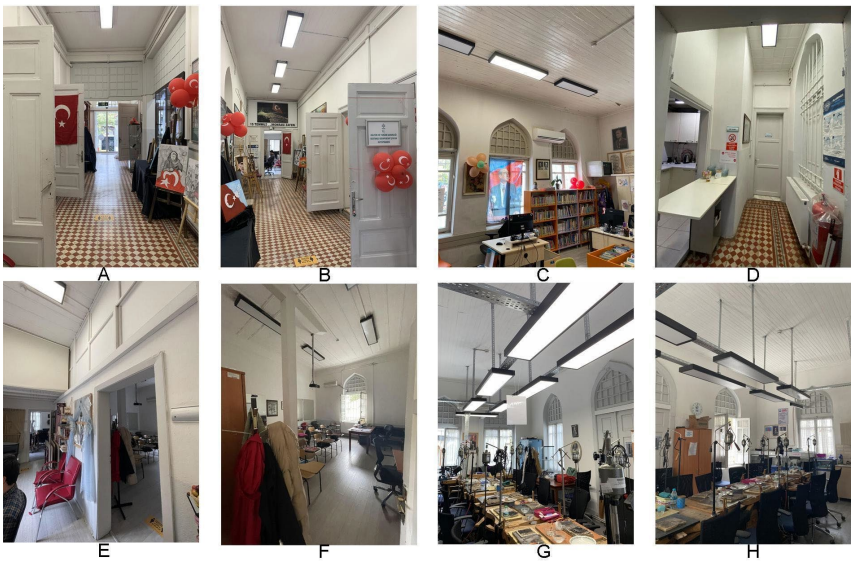


Figure 7 T photographs from the ground floor during the PE

The concentration of stopping points in the hallway on the upper floor is related to its central location within the building, allowing all rooms to be easily perceived from this area (spaces as AR). The window rows (elements as AR) of this narrow hallway (spaces as SR) provide a holistic view of the mosque nearby (elements as SR). The concentration of stopping points in R11 (Figures 8E & 8F) is associated with the changes that have occurred in the building over time, such as the later addition of the wall where the doorway to this room is located and the closure of the original door connecting it to R10 (interventions as SR) (Figure 8C). The concentration in the entrance area of R14 (Figure 8G) is related to its being the first space encountered (spaces as AR) on this floor and receiving ample natural light (spaces as SR).

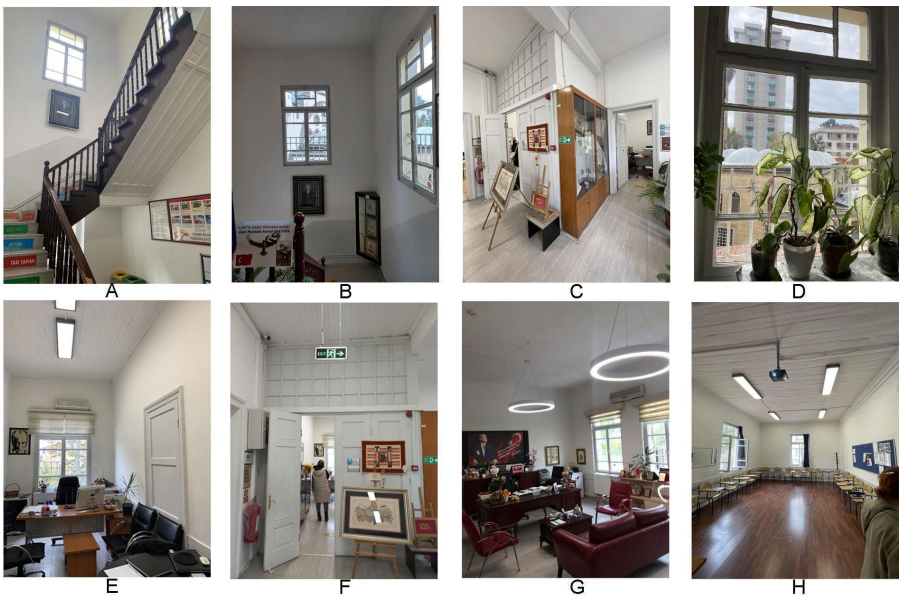


Figure 8 Photographs from the first floor during the PE

Stopping points in the experience outside the building are mainly concentrated on the original few-stepped main entrance (elements as AR) and the courtyard extending from the area between

the mosque and the building to the rear. Therefore, the stopping points regarding the PE seem to be determined in connection with the historical architectural references, such as the original elements and materials of the building (elements as SR and materials as SR), original spaces and changes over time, and the historical atmosphere and environment provided by their holistic perception (spaces as SR).

3.2. Experience 2: Stopping Points of the VRE

Unlike the PE, the stopping points of the VRE appear to be more homogeneously distributed inside the building (Figure 9). Architecture students' familiarity with the virtual reality environment and the representation of spaces with 3D digital models might have been decisive due to the computer-based design tools they used. The VRE of the building may have been perceived as a computer game, regarding the similar experiences of spaces in the games they have already played. The opportunity for free navigation within the VRE inside the building without encountering any physical barriers seems to have been utilised as an advantage. Based on the connection between stopping points and the structural features of the building, especially on the ground floor, similar to the PE, the holistic perception of original architectural elements and materials (elements as SR and materials as SR), spaces, and historical references (spaces as SR) is prominent.

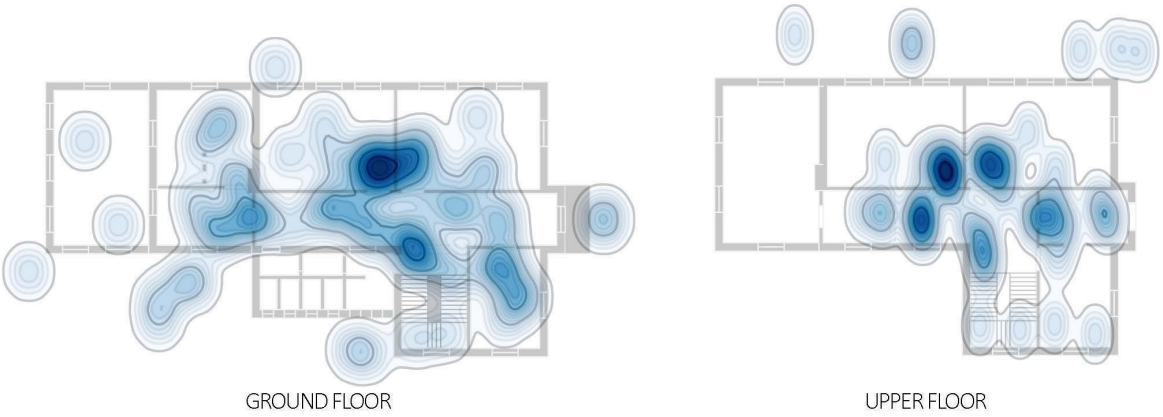


Figure 9 Stopping points of the VRE

The VRE enables spatial exploration by looking from above or outside the building, which is not included in the PE (Figures 13I, 13J, 13K). Significantly, while eliminating physical obstacles such as furnishings in rooms 5 and 11 (Figure 13E), the virtual reality environment allows experiencing some specific areas that cannot be physically experienced (spaces as AR). Even though the movement area during the experience seems more limited in the VRE than the PE, it is associated with the holistic spatial perception in the VR environment, even when stationary at a point.

3.3. Perception 1: Photographing Points of the PE

There is a significant parallelism between the photographing points and stopping points of the PE (Figure 10). The main difference is that various areas within R5 were more accessible for photography due to the closed door between the arched window rows. Another difference is the decreased significance in the photographing points of the entrance area of R14, where the stopping points on the upper floor are concentrated, and a greater concentration of photographing points in the hallway (Figure 8D) leading the stairs. It is due to the perceptibility of the structural integrity of the original wooden staircase (materials as SR), receiving natural light from both sides (elements as SR) and the view towards the mosque. Photographing points are not prevalent in the upper rooms since the window rows are rectangular rather than arched.

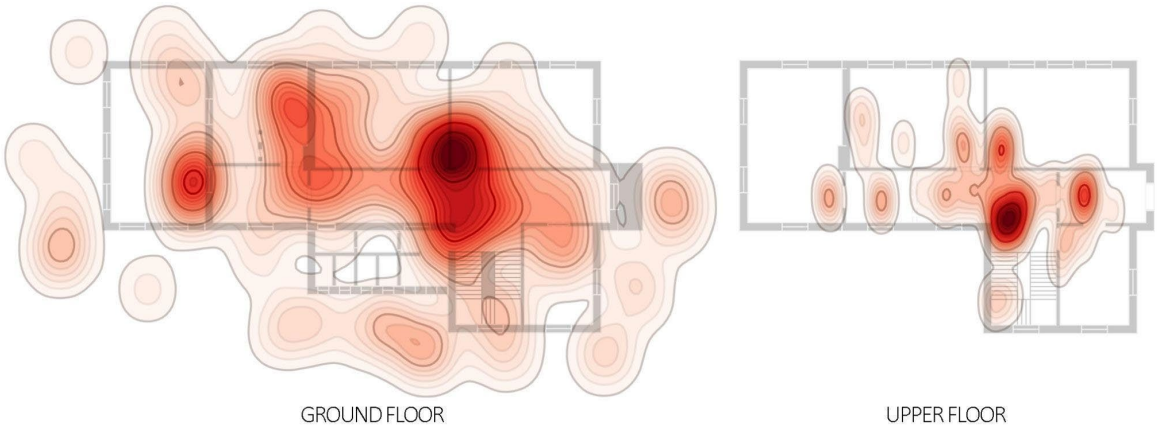


Figure 10 Photographing points of PE

Like stopping points of the PE, the photographing points in the experience outside the building mainly concentrate on the original few-stepped main entrance and architectural details (elements as AR) on the facade (Figure 11). Therefore, the photographing points seem to be determined through the historical view provided by their holistic perception (spaces as SR).

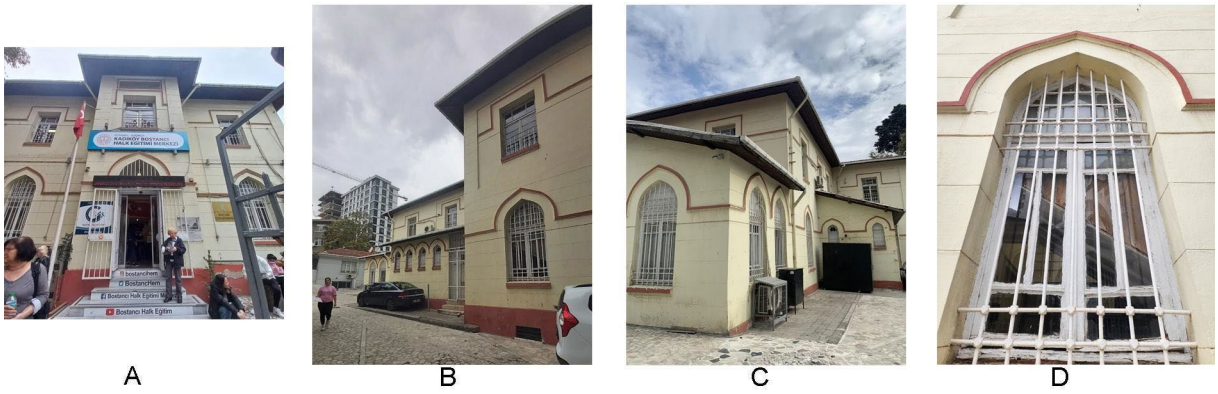


Figure 11 Exterior photographs during the PE

3.4. Perception 2: Screenshotting Points of the VRE

The screenshot points of the VRE are concentrated at a single point (Figure 12) that allows the entire perception of the vertical void defined by the staircase (element as AR and spaces as AR), particularly on the ground floor. The density observed in rooms when photographing physically has become less significant when screenshotting virtually. The density of R2 & R3 (Figure 13E) in virtual stopping points is not included in screenshotting points. No screenshots are taken from the inside of room 5 in the VRE, parallel to the decrease in other rooms. The spatial distribution of photographing points for the building externally tends to decrease in VRE compared to PE, but gathering more specifically at some points.

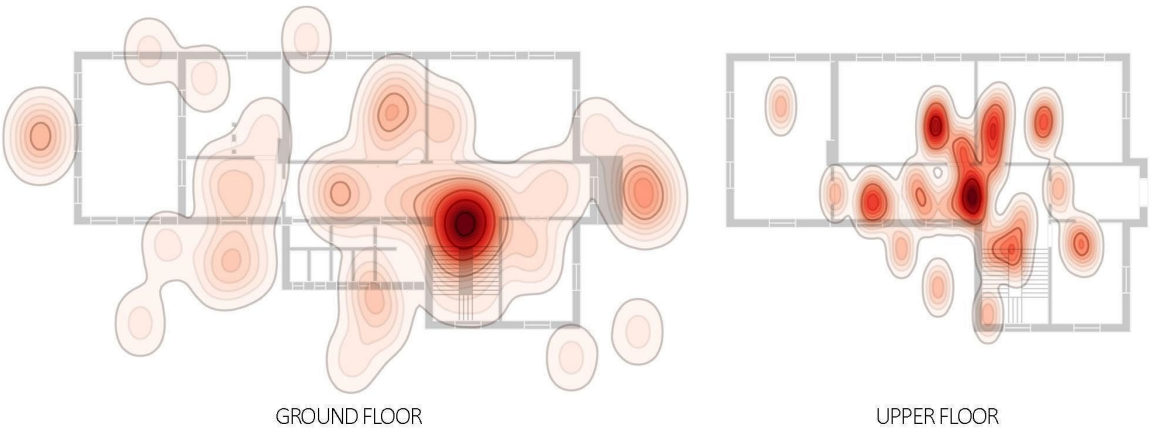


Figure 12 Screenshotting points of the VR

There are no significant differences between the photographing and screenshotting points on the upper floor during both experiences. In the VRE, screenshotting points are concentrated in the area (spaces as AR) leading to the staircase in the upper-floor hallway (Figures 13F, 13G, 13H). The ease of navigating through all spaces without physical barriers in the VR environment has slightly increased the density of screenshot points within R13 & R14. The concentration of photographing points in R12 during the PE has diminished in the VRE by shifting towards R15 along the hallway. The relation to the mosque view through the corridor windows (elements as SR) is also similar when comparing virtual stopping points with screenshotting points.

Despite the virtual stopping points being above the building when perceiving the exterior of the building, they are not included in screenshotting (Figure 13). This seems about the more easily perceivable overall interior in the VR environment. Visuals such as cross-sections and section perspectives of the building among the VRE screenshots have created new perceptions that could never be achieved in the PE.

Figure 13 Screenshots during the VRE

When the written expressions of participants about the reasons for photographing and screenshotting for both PE and VRE are mutually analysed with the visual contents, the senses

created inherently by the architectural and spatial references of the building in their memory are remarkable. Among the specified reasons for taking photographs and screenshots, elements, materials (a variety of original ones and later additions), historical details (arched windows and doors, columns, decorative elements), and recent interventions (spatial arrangement of the new function, decorative objects) are included.

3.5. Memory 1 & 2: Sketching Points of the PE & VRE

Two main points are noticeable when the sketches made after PE and VREs are analysed (Figure 14 & Figure 15): (1) details related to architectural elements (elements as AR) and (2) overall views of the facades (elements as AR). Sketches mainly include historic architectural elements such as the original staircase, wooden details, pointed arched window rows and decorative elements (elements as AR). The newly added columns, doors that closed and lost their function, and later additions related to the newly spatial arrangements of the building over time are also prevalent among the sketches (interventions as SR). However, the sketches do not represent any recent architectural interventions.

Figure 14 Sketches after the PE

In the sketches of the VRE, the drawings of the facades are included more extensively in a general view concerning the scaling and holistic perception opportunity provided by the virtual reality environment. No significant difference is included between PE and VREs in sketches of the specific spaces containing architectural references. It stands out that the accumulation of historical layers and references in the memory and the reflexes regarding the spatial perception of being an architecture student.

Figure 15 Sketches after the VRE

4. Results and Findings

Experiencing the building both physically and virtually and describing these experiences through multiple forms of representation revealed a multi-layered structure of memory formation, supporting both individual perception and collective accumulation. This framework, where architectural references are interpreted through episodic memory and sensory references through semantic memory (Figure 16) is parallel with Slater and Wilbur (1997), who emphasize that virtual environments foster episodic encoding, while real-world sensory input triggers deeper semantic associations.

EXPERIENCE	TASK	VALUE	OVERALL	VALUE	VIRTUAL/PHYSICAL	VALUE	TASK RELATED	VALUE	OVERALL	VALUE	VIRTUAL/PHYSICAL	VALUE
VIRTUAL	SCREENSHOTS	0,2	ARCHITECTURAL REFERENCES	0,316	ARCHITECTURAL REFERENCES	0,165	ARCHITECTURAL REFERENCES	0,13	ELEMENT	0,202	ELEMENTS	0,11
							SENSES	0,07			SPACES	0,098
	SKETCH	0,05			SENSES	0,085	ARCHITECTURAL REFERENCES	0,035	SPATIAL	0,164	INTERVENTIONS	0,026
							SENSES	0,015			MATERIALS	0,018
PHYSICAL	PHOTO	0,182	SENSES	0,181	ARCHITECTURAL REFERENCES	0,151	ARCHITECTURAL REFERENCES	0,1	INTERVENTION	0,086	ELEMENTS	0,092
							SENSES	0,082			SPACES	0,066
	SKETCH	0,065			SENSES	0,096	ARCHITECTURAL REFERENCES	0,051	MATERIAL	0,05	INTERVENTIONS	0,06
							SENSES	0,014			MATERIALS	0,032

Figure 16 Page rank values of each parameter

When participants' photographs, screenshots, sketches, and verbal outputs were analyzed through their repetition frequency and visual links (as visualized in Graph Commons), architectural references (0.316) emerged 1.74 times more recognisable than sensory references (0.181). This suggests that participants rely more on their episodic memories, regardless of their environment. And it supports Cummings and Bailenson's (2016) observation that spatial legibility and clarity in VR lead to enhanced cognitive mapping and spatial memory, even when multi-sensory feedback is limited. However, the interpretive reflexes of the architecture student participants, as highlighted in Mikropoulos and Natsis (2011), may have played a reinforcing role in prioritizing architectural impressions over sensory ones.

More specifically, architectural references in VRE (0.165) exceeded those in PE (0.151), likely because VR eliminated the physical and perceptual barriers of real-world navigation, allowing the building to be perceived effectively as a whole. On the contrary, sensory references in PE (0.096) were more prominent than in VRE (0.085), which supports Pallasmaa's (2007) assertion that physical experience engages the full body and sensory memory -including touch, atmosphere, and temperature- which VR still cannot fully replicate. Individual internalisation based on direct touch

and immersive feeling through the historical atmosphere in-real and the sense of belonging to and the social-cultural awareness of the historic building provided by the PE triggered semantic memory. Moreover, the perception focuses on architectural elements, spaces, interventions, and materials in both experiences (Figure 17), where meaning and materiality become integrated over time.

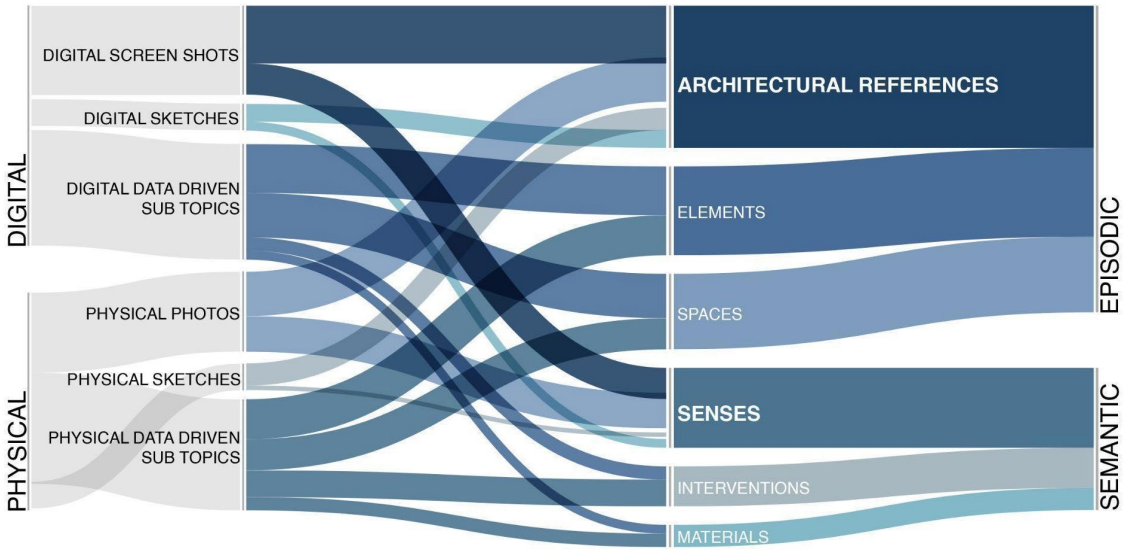


Figure 17 Relational analysis of parameters

In the analysis of subcategories, architectural elements (0.11) and spatiality perception (0.098) were more prominent in VRE, while interventions (0.06) and materials (0.032) were more vivid in PE. This further indicates the episodic and semantic memory distinction and is consistent with Brewer (1986) study that emotionally salient or symbolically charged elements are more likely to be encoded into long-term memory. Despite the dominance of sensory references in both experiences, participants consistently expressed architectural references more frequently in their post-experience sketches, especially in the PE, similar to Pallasmaa's (2007) theory that drawing is an extension of embodied memory and also visual and tactile cognition. Additionally, it reveals the superiority of VRE over PE and episodic memory over semantic memory through the perception of a historical building.

On the other hand, when different representations in PE and VRE experiences such as photographs, screenshots and sketches are examined in detail, architecture is used to activate memory through senses, with all its visual and physical features. In PE and VRE, participants' stopping points are not arbitrary but meaningful about the conceptual content of the architecture and space and its material existence. The exact places they prefer as stopping points are those where they can best perceive the historical and semantic qualities of the space, which is related to the recall and remembering processes of memory. The participants tended to perceive a past physically they had never experienced through these concrete architectural signs on the historical building that do not belong to the present, such as the entrance hall, staircase, courtyard, doors and windows. These were not arbitrary but selected according to their memory's need for symbolic anchors, echoing Assmann's (1997) notion of cultural and collective memory, in which historically embedded architectural elements act as figures of memory that transcend time and space. So these architectural elements, primarily perceived through the sense of sight, have gained a broader content related to semantic memory in the participants' minds beyond visual elements through the images they create by activating the senses.

Since the architectural images photographed focus on the participants' perceptions of the environment, its content is produced consciously and individually. However, although they present a focused view of the widest environment in which the individual is located, they are produced as

visual images that will include the space and the unique atmosphere created by this space in the most specific way. In this context, the senses created inherently by the architectural and spatial references of the historic building in their memory individually seem to have been decisive in determining the photographing and screenshotting points. Although there are differences between PE and VRE, the perception of the concreteness of the space by integrating all senses and the determination of the focused vision by associating images with an experienced or inexperienced past in mind are related to memory. However, in this experience, the presentation of focused visions as an accumulation of historical references reveals the relationship of the past established with memory through recalling. Participants' tendency to focus on past-related, historical features of the building (e.g., original windows, materials, decorative elements) instead of recent interventions, and their inclusion only of historical elements in sketches in both PE and VRE, reflect Crinson's (2005) framing of architecture as a palimpsest of memory. Ultimately, the act of sketching and photographing these spaces suggests an attempt to reconcile personal perception with cultural continuity -a process described by Brewer (1986) as the transformation of sensory input into symbolic memory through visual imagery. On the other hand, the holistic presentation of the drawings reveals the role of the visual images and symbol of remembrance in memory recall. Especially given their educational background, it demonstrates how collective memory and architectural training intersect, making the experience both personally reflective and historically rooted. It also refers to Assmann's (1997) view that what is remembered is often shaped by collective references rather than present functionality. This reinforces the idea that participants, even when navigating virtually, were oriented toward memory-laden elements of the architecture, guided by urban memory embedded in Istanbul's architectural fabric, even though they did not spatially experience them before.

To facilitate a clearer comparison of perceptual tendencies across environments, Table 1 summarizes the relative intensity of architectural references (AR) and sensory references (SR), including their subcategories, in both physical and virtual experiences. It also presents Wilcoxon signed-rank test results to evaluate statistical significance (Field, 2018; Gibbons & Chakraborti, 2011).

Table 1 Statistical Comparison of Recognition Intensity (*p < 0.05; †p < 0.10 trend-level significance)

Comparison	PE Mean	VRE Mean	Wilcoxon Statistic	p-value	Significance
AR: overall	0.151	0.165	-	0.036	*
AR: elements	0.0937	0.1058	58.0	0.0826	†
AR: spaces	0.0727	0.0948	20.0	0.0007	*
SR: overall	0.096	0.085	-	0.105	
SR: interventions	0.0611	0.0254	1.0	0.0000	*
SR: materials	0.0347	0.0186	19.0	0.0006	*

The results showed that the difference in architectural reference (AR) recall between PE and VRE was statistically significant (p=0.036), indicating that VRE notably enhanced the recall of architectural elements. For sensory references, the difference was not statistically significant (p=0.105), though a slight tendency toward greater sensory recall in PE was observed. These results align with our qualitative findings suggesting that VRE more effectively triggers episodic memory, while PE engages semantic and sensory memory more.

Analysis of subcategories offers a nuanced understanding of memory patterns. The recall of spatiality perception under architectural references was significantly higher in VRE (p=0.0007), whereas the recall of architectural elements approached significance (p=0.083). In contrast, participants recalled sensory details such as interventions (p=0.000004) and materials (p=0.0006) significantly more in the physical environment. These findings suggest that VRE enhances spatial

understanding and episodic recall, while PE provides a richer engagement with tactile and material aspects associated with semantic memory.

5. Discussion

Designed by Kemalettin to serve the needs of a modernizing education system in the early 20th century, the Bostancı Primary School building continues to stand as a well-preserved architectural artifact shaped by the evolving socio-cultural dynamics of its era. Although the building has undergone functional transformations and spatial alterations over the years, its original architectural stylistic characteristics -arched windows and doors, wide eaves, symmetrical facades, wooden staircases, and ornamentations- remain largely intact. These enduring features render the structure not only a representation of architectural heritage but also a mnemonic medium that anchors both individual and collective urban memory.

The findings of this study reinforce the notion that different memory types are activated depending on the nature of the experienced environment, in architectural terms. Specifically, the results indicate that virtual reality experiences (VRE) facilitate stronger recall of spatial and structural aspects (episodic memory), while physical experiences (PE) elicit greater retention of tactile and material details (semantic and sensory memory). These patterns are consistent with recent research suggesting that embodied spatial exploration in VR enhances episodic memory formation through immersive interaction and self-directed navigation (Slater & Wilbur, 1997; Cummings & Bailenson, 2016).

The results demonstrate a precise alignment between the study's methodology and its theoretical underpinnings. The statistically significant enhancement of spatial recall in the virtual reality environment (VRE), particularly for spatial configurations ($p=0.0007$), reflects Pallasmaa's (2007) argument that architecture is not merely visual but multi-sensory and experiential. While VR may lack haptic input, its immersive capacity strengthens episodic memory by enabling embodied navigation supporting Pallasmaa's notion of the "lived body" as the locus of architectural experience. The emphasis on spatial memory in VR also parallels the emphasis on the primacy of atmosphere and spatial continuity in perception.

Participants demonstrated significantly higher recall of spatial features in VRE settings ($p=0.0007$), while materials and interventions were more accurately remembered following physical exposure ($p<0.001$). This suggests that memory recall in architecture is multidimensional, shaped not only by content (what is remembered) but also by the sensory and cognitive characteristics of the medium (how it is experienced). The architectural memory is not merely about recognizing form but about engaging with space through perception, embodiment, and meaning. The richer recall of materials and interventions in the physical experience (PE) -with significant differences ($p=0.000004$ and $p=0.0006$)- echoes Crinson's (2005) view that architecture is always embedded in cultural and material histories. As physical experience triggers tactile sensations, it allows for a more nuanced engagement with textures, interventions, and decay -elements that often resist full simulation in virtual environments. These tactile and body-mediated interactions align more with semantic memory, where accumulated knowledge and cultural context shape perception. This confirms that PE engages long-term memory and knowledge-based recall.

Furthermore, Assmann's (1997) theory of cultural memory becomes particularly relevant in interpreting how specific features of the Bostancı Primary School -such as arched windows, decorative elements, or wooden stairs- were consistently remembered across both mediums. These elements function as "figures of memory" that anchor collective remembrance. The fact that participants retained memory of these symbolic elements regardless of medium suggests that architectural symbols embedded in cultural memory transcend the experiential limitations of either PE or VRE. Thus, the methodology of comparing episodic (VR) and semantic (physical) memory modes not only reflects but also operationalizes Assmann's theoretical separation of communicative vs. cultural memory within a spatial and architectural context.

These findings have significant practical implications for architectural education and heritage preservation. Virtual reality can be a powerful tool for teaching spatial awareness and design principles, especially in settings where physical access to historical sites is limited. However, it should not be seen as a substitute for physical interaction. Instead, it should be viewed as a complementary medium that can enrich architectural pedagogy when integrated alongside traditional site visits and tactile experiences.

By integrating qualitative and statistical analyses, this study does more than comparing positive or negative features of different mediums; it traces how different modalities access distinct layers of architectural memory: VR reinforcing experiential immediacy, and PE reinforcing cultural-physical depth. This layered reading validates the multi-method approach adopted and reaffirms the theoretical foundations laid by key scholars in memory and architecture.

While this study has certain limitations, it also opens up valuable paths for future research. Firstly, the participant sample consisted of senior architecture students with relatively similar backgrounds in spatial cognition and drawing skills. Expanding future studies to include a more diverse participant pool -such as practitioners, non-specialists, or individuals from various age groups and backgrounds- could offer a broader understanding of architectural memory. Secondly, although this research employed a strong qualitative framework and relational mapping tools, incorporating different statistical modelling in future work could enhance the generalizability of the findings. Nevertheless, the relational mapping of memory sketches, verbal descriptions, and image annotations yielded rich, triangulated insights into how individuals encode and recall architectural environments.

The methodology and findings of this research contribute a novel framework for evaluating the memory of historical environments through comparative physical and virtual experiences. As the boundaries between real and simulated environments continue to blur in both education and design practice, understanding how memory operates across these media becomes increasingly relevant. This study lays the groundwork for future explorations on perceptual depth, spatial cognition, and memory formation, potentially extending to interdisciplinary domains such as environmental psychology, digital heritage, and experiential learning.

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CRediT Authorship Contribution Statement

Yekta Özgüven: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Asena Kumsal Şen Bayram: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Nadide Ebru Özkan: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

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