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Neuro-Spatial Legibility and Perceived Navigational Stress in Educational Environments: An Exploratory Qualitative Assessment Framework

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Abstract

Cognitive processing, emotional regulation, and navigational behavior are influenced by spatial organization and environmental stimuli in educational environments. Research in neuro-architecture, environmental psychology, and spatial analysis has increasingly demonstrated the relationship between built environments and human cognition. However, existing methods provide limited practical means for systematically evaluating spatial conditions associated with anxiety in educational settings. This study addresses this gap by developing and applying the Neuro-Spatial Legibility Assessment Framework (NSLAF), a qualitative method integrating Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC). NSLAF follows a three-phase protocol comprising spatial mapping, structured environmental assessment, and interpretive synthesis. The framework was applied to Lycée de Ben Arous, a public secondary school in Tunis, Tunisia, through a qualitative case study supported by architectural analysis, circulation mapping, structured observation, sensory assessment, a pilot student perception survey (n = 30), and comparison with a reference school. Findings identified locations associated with heightened neuro-spatial strain, particularly circulation intersections, entrance thresholds, and visually repetitive movement sequences. These areas showed reduced spatial legibility, greater sensory demands, unclear transitions, navigational uncertainty, and increased cognitive demand. Convergence among architectural observations and student perceptions supported NSLAF's internal consistency. The framework provides a qualitative methodology for identifying neuro-spatial challenges and informing evidence-based interventions in existing educational environments.

Keywords*:* Neuro-architecture; Spatial Legibility; Neuro-Spatial Strain; Wayfinding; Educational Environments; Qualitative Assessment

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1. Introduction
1.1 Background and Context

Architecture influences human experience not only through its structural design, but also through the perception, interpretation and navigation of constructed spaces. It influences how students and staff move through space, how they feel about it, how they behave inside of it and their mental health and wellbeing while using it. Educational institutions are thus a prominent environment for investigating the impact of spatial features on everyday learning experiences and academic outcomes (Barrett et al., 2015; Tanner, 2009; Woolner et al., 2007; Maxwell, 2016). Neuro-architecture and environmental psychology are progressively revealing how the constructed environment influences cognitive and emotional functions, shaped by the interplay of spatial arrangement, sensory conditions, and environmental predictability (Evans & McCoy, 1998; Sternberg, 2009; Higuera-Trujillo et al., 2021; Abbas et al., 2024). Orientation, focus, stress management, and cognitive efficacy are related to architectural elements like circulation hierarchy, environmental clarity, sensory engagement, and spatial coherence (Ulrich, 1984; Tawil & Kühn, 2024; Attaianese et al., 2025). Meanwhile, environments typified by fragmented movement patterns, absence of environmental indications, poor spatial organization, and excessive sensory input may heighten navigational uncertainty, cognitive strain, and psychological discomfort (Evans & McCoy, 1998; Higuera-Trujillo et al., 2021). These contextual elements are especially significant in educational contexts that need to accommodate a variety of cognitive and sensory requirements. Expected spatial configurations, agreeable sensory environments, and logical movement schemes can enhance users' perception of the environment and aid their wayfinding and wellbeing. On the contrary, chaotic or overstimulating surroundings may disrupt these systems (Barrett et al., 2015; Hamilton & Watkins, 2009; Abbas et al., 2024; Kazak & van Hoof, 2025). Neuro-spatial sensations are generally associated with specific architectural features, but increasingly are understood as the result of the interaction of many environmental parameters. How educational environments are spatially organized, the sensory circumstances they offer and the continuity of transitions impact the way users perceive, interpret and move through these places. Thus, it is imperative to comprehend architectural organization not only as a mechanism of functional circulation, but as a cognitive-spatial framework that influences environmental predictability, perceived cognitive load, and daily experiences (Higuera-Trujillo et al., 2021; Tawil & Kühn, 2024; Attaianese et al., 2025).

1.2 Problem Statement and Research Gap

Significant advances have been achieved in the fields of neuro-architecture and environmental psychology, but evaluation methodologies of educational environments still are isolated. Current methodologies, including Space Syntax, Post-Occupancy Evaluation (POE), wayfinding research, and sensory-responsive design frameworks, typically assess spatial arrangement, user experience, navigation, and sensory factors independently, rather than as interrelated components of a cohesive environmental system.

Space Syntax provides powerful evaluations of spatial configurations and movement patterns, but does not take into account sensory environments and cognitive-spatial experiences of individuals. In contrast, POE deals with occupants' opinions of the performance of the environment but does not systematically link these perspectives to physical configuration. Similarly, the sensory responsive design paradigms are mostly focused on the inputs from the environment ignoring issues such as hierarchy of circulation, continuity of transition, and architectural clarity. Thus, the few evaluating techniques embed spatial arrangement, sensory control, and transitional transparency to analyze the neuro-spatial stress in contemporary educational environments. This methodological shortcoming is not a trivial matter in modern schools where large scale activities are sometimes hampered by operational, financial or heritage constraints. Architects and policy makers need evaluation techniques that can detect environmental components linked with greater neuro-spatial stress and guide focused, data-driven changes. By combining spatial, sensory and transitional aspects into an integrated framework, we may more effectively study and improve educational environments.

1.3 Research Objectives

This study fills this gap by proposing the Neuro-Spatial Legibility Assessment Framework (NSLAF), a systematic qualitative technique that leverages neuro-architectural principles to assess contemporary educational contexts. NSLAF does not suggest design ideas for new institutions, but rather provides a systematic framework for analyzing existing educational environments using three interconnected analytical dimensions:

- Spatial Legibility (SL)
- Sensory Regulation (SR)
- Transitional Clarity (TC)

Collectively, these dimensions encompass fundamental characteristics of architectural arrangement affecting direction, sensory perception, flow of movement, and perceived cognitive burden. NSLAF provides a systematic approach for a unified examination to discover environmental elements linked with neuro-spatial stress.The framework was implemented in a public high school in Tunis, Tunisia, the Lycée de Ben Arous. The diversity of its sensory settings, the complexity of its transitional sequences, and the recurring circulation patterns give the ideal context for the first implementation and evaluation of the suggested methodology.
Hence, the present study intends to answer the following questions:

1. ***What is the spatial structure and neuro-spatial strain in educational environments?***
2. ***Which architectural features are most typically associated with higher perceived cognitive load, uncertain navigation and neuro-spatial stress?***
3. ***How to codify the notions of neuro-architecture in a qualitative methodology to evaluate the existing educational environments ?***

1.4 Significance and Structure of the Paper

In three main ways this work contributes to the emerging field of neuro-architecture. Methodologically, it offers the Neuro-Spatial Legibility Assessment Framework (NSLAF), which through a rigorous qualitative procedure for assessment of educational environments integrates Spatial Legibility, Sensory Regulation and Transitional Clarity. It implies that schools function as integrated cognitive-spatial systems, with architectural configuration influencing wayfinding, environmental predictability, and neuro-spatial stress. In reality, it offers architects, planners and educational policy makers an empirical evaluation tool to identify neuro-spatial barriers and to guide specific interventions, especially when full reconstruction is not feasible.

Figure 1 shows the basic research method. The research gap is defined and the theoretical framework is developed. Then the development of NSLAF is explained and implemented in the case study. A full assessment, review of the findings and recommendations are set out below.

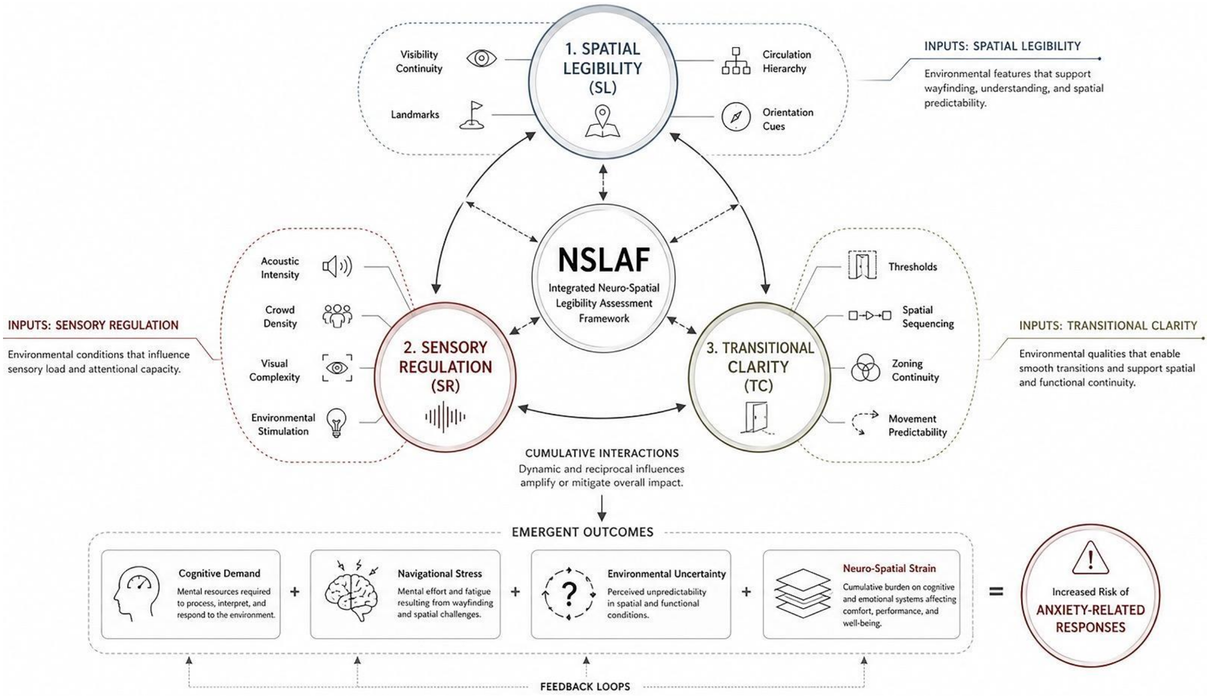

Figure 1. Structure of the study.

Research process showing the process of research gap identification, theoretical foundation development, development of Neuro-Spatial Legibility Assessment Framework (NSLAF), application on the case study, multidimensional assessment using Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC), result interpretation, conclusion and recommendation.

The rest of this paper is arranged as follows. The principles behind NSLAF are discussed in Section 2. Section 3 discusses the research approach and the case study. Evaluation results are given in Section 4. The results are reviewed in Section 5 with respect to the existing literature. Section 6 ends the report with a summary of the main findings, including limitations of this study and ideas for future research.

2. Materials and Methods

2.1 Study Design and Setting

The research strategy was qualitative case study design using methodological triangulation to explore the impact of architectural features on neuro-spatial experiences in an educational setting. Instead of explicitly evaluating psychological or clinical outcomes, the study explored how spatial structure, sensory circumstances and movement sequences interact to determine environmental comprehension, navigational effort, perceived cognitive load, and neuro-spatial strain. Qualitative methods are especially suited to investigate complex person-environment relationships in real-world settings and are in line with existing research in environmental psychology, wayfinding and neuro-architecture (Gifford, 2007, 2014; Higuera-Trujillo et al., 2021; Abbas et al., 2024).

The empirical study was carried out in Lycée de Ben Arous, a public secondary school located in the metropolitan area of Tunis, Tunisia. The school was purposively sampled because it displays architectural features often linked to navigation and environmental cognition, such as long corridors, repetitive spatial morphology, few visual differences, fragmented circulation networks, and contrasting sensory environments (Lynch, 1960; Weisman, 1981; Passini, 1992; Devlin, 2014). Such traits provided an ideal framework for a first application of the Neuro-Spatial Legibility Assessment Framework (NSLAF) to an existing educational setting.

To enhance methodological rigor, the study integrated multiple sources of evidence, including architectural analysis, structured field observations, sensory environment assessment, a pilot student perception survey, and qualitative comparison with a reference secondary school exhibiting stronger spatial organization. Methodological triangulation could allow exploration of environmental variables from both a physical, observational and perceptual perspective and minimise reliance on one source of evidence. The above integrated strategy is in line with current neuroarchitectural research that promotes the combination of different forms of environmental assessment in order to better understand the relationship between architectural characteristics and cognitive experience (Higuera-Trujillo et al., 2021; Abbas et al., 2024; Attaianese et al., 2025).

As indicated in Figure 2, the study workflow comprised five consecutive stages: (1) architectural documentation and spatial analysis, (2) structured field observations, (3) sensory environment assessment, (4) a pilot student perception survey, and (5) comparative benchmarking. Results from these phases of work were combined in NSLAF to evaluate Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC) and to identify environmental factors that may be related with neuro-spatial strain.

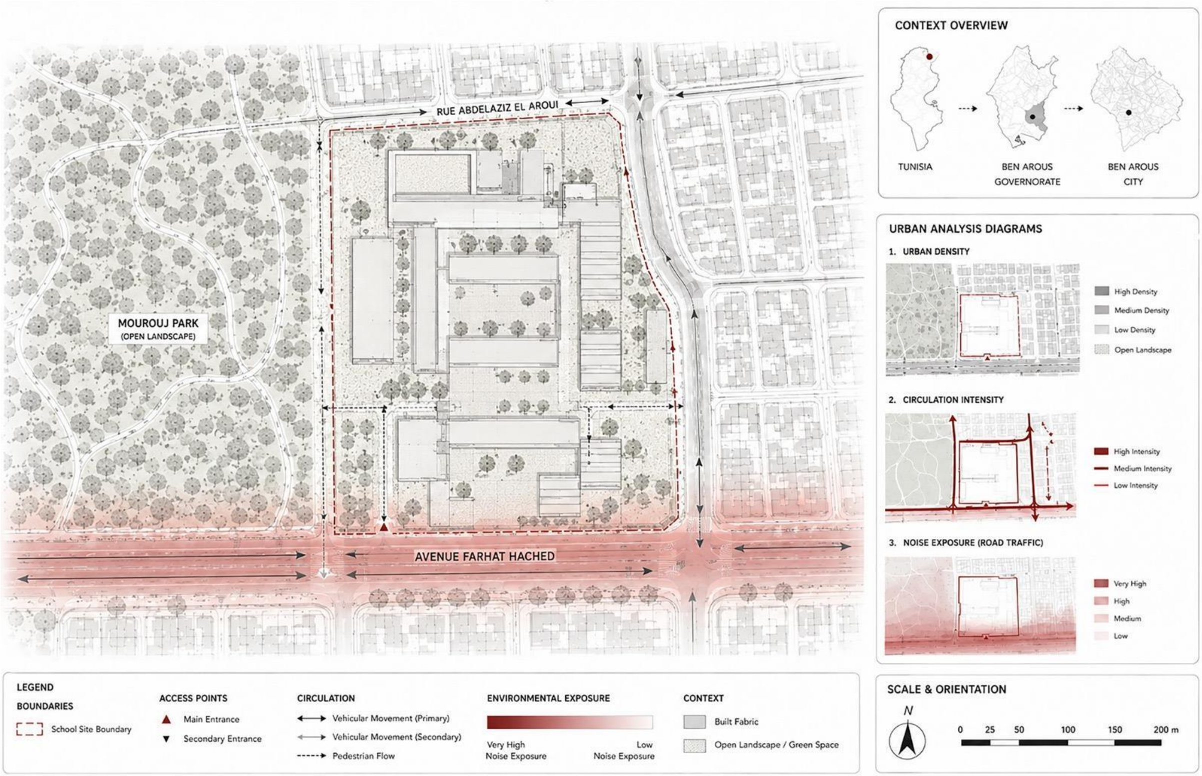

Figure 2. Spatial and Urban Context of Lycée de Ben Arous, Tunis.

Research workflow overview showing the step-by-step integration of architectural analysis, organized field observations, sensory environment evaluation, pilot student perception survey, and comparative benchmarking inside the Neuro-Spatial Legibility Evaluation Framework (NSLAF). The approach synthesizes numerous sources of information to evaluate Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) to help identify environmental circumstances linked with neuro-spatial strain.

2.2 Study Environment and Participants

The constructed environment of Lycée de Ben Arous was the main unit of analysis, especially its circulation system, transitional spaces and sensory conditions. The campus consists of interlinked classroom blocks which are designed around open courtyards and linear circulation paths. The layout provides functional connectedness, but its repetitive architectural language, low visual distinction, and poor circulation hierarchy weaken environmental distinctiveness and increase reliance on learnt rather than intuitive navigation. These features have been extensively linked to environmental legibility, wayfinding performance and cognitive mapping, making the school an appropriate context in which to investigate neuro-spatial strain (Lynch, 1960; Weisman, 1981; Passini, 1992; O'Neill, 1991; Devlin, 2014; Erkan, 2024; Hillier & Hanson, 1984).

To support the architectural assessment a pilot perception survey was carried out with 30 students' volunteers (n = 30). Participation was voluntary, anonymous and no personally identifiable information was collected. The questionnaire consisted of a five-point Likert scale from Strongly Disagree (1) to Strongly Agree (5) to investigate participants' views on navigational difficulty, environmental predictability, perceived cognitive demand and neuro-spatial strain during routine movement across the school.

The poll was aimed to provide complementing views from users, rather than statistical or clinical proof. The responses were therefore regarded as subjective measures of environmental experience and were analyzed in conjunction with the architectural analysis and the structured field observations as part of the methodological triangulation.

The study was performed according to institutional research norms and did not require formal ethical approval, as there were no interventions or collection of personal health information, and the perception data were anonymous and the environmental observations were non-invasive.

2.3 Materials and Data Sources

The study used several kinds of evidence to describe the physical, observational and perceptual properties of the educational environment. The credibility of the assessment was further improved by combining architectural, observational, sensory and user-based data, which allowed conclusions to be compared and understood across multiple perspectives. This multimethod approach aligns with recent neuroarchitectural research emphasizing the value of integrating multiple types of environmental evidence to enhance understanding of cognitive and sensory experiences within the built environment (Higuera-Trujillo et al., 2021; Abbas et al., 2024; Attaianese et al., 2025; Kazak & van Hoof, 2025).

The architectural documentation, such as floor plans and site layout, was studied to analyze circulation networks, spatial hierarchy, visibility linkages, orientation cues, and movement sequences across the campus. These analyses established the geographical basis for the assessment of Spatial Legibility (SL) and the determination of the architectural characteristics associated with navigation and environmental understanding (Evans & McCoy, 1998; Higuera-Trujillo et al., 2021).

Structured field observations were undertaken with standard recording sheets created for the NSLAF technique. The observations registered the movement flow, bottlenecks, choice of direction, conflicts of circulation and habits of movement of the navigation in the normal functioning of the school. All observations were performed by the lead investigator throughout several site visits to ensure uniform application of the assessment criteria.

Sensory circumstances were assessed by systematic monitoring of noise exposure, visual complexity, illumination consistency, crowd density, and the nature of transitional areas. These observations were used to evaluate Sensory Regulation (SR) and Transitional Clarity (TC). The current neuro-architectural approaches acknowledge the impact of sensory and perceptual conditions on users' experience of the environment (Mostafa, 2014; Shemesh et al., 2017; Abbas et al., 2024).

To promote contextual understanding, a qualitative comparison was made with Caudwell International Children's Centre, which presented a stronger spatial organization and environmental legibility. The reference project was not an experimental control, but a baseline for interpreting the observations in the case-study environment.

Finally, the pilot perception survey responses furnished complementary information on navigational difficulties, environmental predictability, perceived cognitive load, and neuro-spatial strain. Architectural analyses, field observations, sensory assessments and survey responses were systematically recorded using architectural drawing software (Autocad, Photoshop) and spreadsheet-based templates (Microsoft Excel) to ensure consistency, transparency and traceability throughout the assessment process.

2.4 Neuro-Spatial Legibility Assessment Framework (NSLAF) Protocol

The Neuro-Spatial Legibility Assessment Framework (NSLAF) was created as a structured qualitative methodology to assess existing educational environments from the neuro-architectural perspective. In contrast to traditional assessment methods that usually examine spatial configuration, environmental performance, or sensory conditions in isolation, NSLAF assesses how these complementary characteristics interact to affect environmental understanding, navigation, and neuro-spatial strain. The framework is organized around three integrated dimensions, Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC), which together provide a comprehensive basis for assessing cognitive-spatial performance in educational settings (Lynch, 1960; Weisman, 1981; Passini, 1992; Devlin, 2014; Hillier & Hanson, 1984; Erkan, 2024).

The NSLAF was developed by synthesizing the concepts of wayfinding theory, environmental psychology, spatial configuration analysis, sensory-responsive design, and contemporary neuro-architecture (Lynch, 1960; Weisman, 1981; Passini, 1992; Mostafa, 2014; Higuera-Trujillo et al., 2021; Abbas et al., 2024; Attaianese et al., 2025). Rather than a replacement of preexisting methodologies, the framework integrates their complementary qualities within a unified procedure for examining existing educational environments from a neuro-architecture-informed perspective.

The approach is premised on the notion that neuro-spatial strain is a product of the cumulative interaction of architectural and environmental factors rather than discrete spatial deficits. Thus, the NSLAF measures three complementary dimensions:

- **Spatial Legibility (SL)** measures the clarity of the spatial organization, the hierarchy of circulation, the visibility relationships, the orientation cues, the distribution of landmarks, and the overall readability of the environment that together facilitate intuitive navigation and environmental understanding (Lynch, 1960; Weisman, 1981; Passini, 1992).
- **Sensory Regulation (SR)** is the assessment of the quantity, quality, and continuity of environmental stimuli, including noise levels, lighting, visual complexity, and the number of people present, which affect the cognitive load and the level of comfort within the environment (Mostafa, 2014; Higuera-Trujillo et al., 2021; Abbas et al., 2024).
- **Transitional Clarity (TC)** refers to the continuity of sequences of movement, the definition of thresholds, the coherence of zoning and the predictability of spatial transitions that enable orientation and continuous movement throughout the environment (Passini, 1992; Hillier & Hanson, 1984; Higuera-Trujillo et al., 2021).

These three variables are combined in NSLAF to provide a complete neuro-spatial profile that is useful to identify and understand the environmental circumstances related with neuro-spatial strain. A more comprehensive assessment can be attained by considering spatial organization, sensory circumstances, and transitional continuity together than by assessing each attribute separately.

Figure 3 shows the conceptual structure of NSLAF and the interaction between its three assessment dimensions.

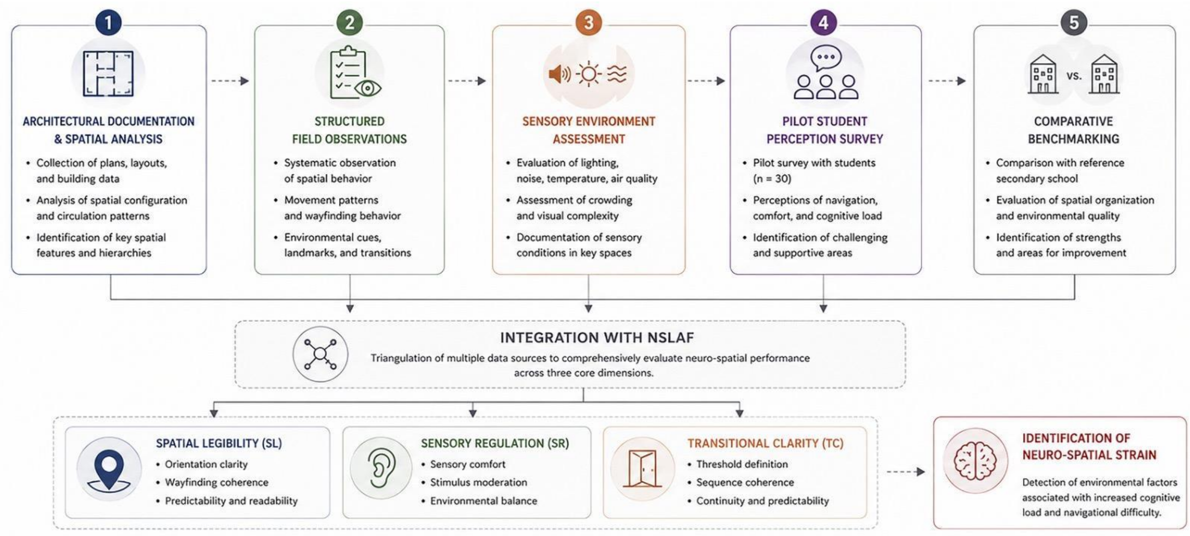

Figure 3. Conceptual Structure of the Neuro-Spatial Legibility Assessment Framework (NSLAF).

Conceptual framework of Neuro-Spatial Legibility Assessment Framework (NSLAF) representing the relationship between Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC).

These complementary dimensions together generate a neuro-spatial profile that integrates the identification and interpretation of environmental conditions associated with neuro-spatial strain in educational environments.

2.4.1 Development of the Neuro-Spatial Legibility Assessment Framework

The development of NSLAF was an iterative process in four stages . Theoretical synthesis and empirical refinement were combined to ensure conceptual coherence and practical applicability. Fig. 4 summarizes the overall development process.

Stage 1 – Theoretical Basis

To this end, an extensive review of research on wayfinding, environmental psychology, spatial cognition, sensory-responsive design, and neuro-architecture was performed to identify architectural characteristics that are consistently correlated with navigation, environmental comprehension, cognitive demand, and neuro-spatial experience (Lynch, 1960; Weisman, 1981; Passini, 1992; Hillier & Hanson, 1984; Mostafa, 2014; Higuera-Trujilo et al., 2021; Abbas et al., 2024).

Phase 2 – Indicator creation

The architectural factors from the literature were methodically clustered into larger conceptual domains reflecting complementing levels of environmental cognition. This procedure led to the delineation of the three fundamental NSLAF dimensions: Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC).

Stage 3 – Operationalization of Framework

The preliminary framework was applied iteratively to the selected case-study environment, to evaluate the clarity, relevance and practical observability of each assessment indicator. Indicators that could not be consistently recognized by architectural analysis or structured field observation were refined or merged to improve operational consistency.

Stage 4 – Application and Triangulation of Methods

The modified framework was subsequently applied using a triangulated technique that integrated architectural analysis, structured field observations, sensory environment evaluation, a pilot student perception survey, and qualitative benchmarking with Caudwell International children's center. The convergence of these multiple evidence sources enhanced the interpretive robustness of the assessment and supported the practical deployment of NSLAF in an existing educational system.

This iterative process guaranteed that NSLAF was anchored in known theoretical ideas, while also providing a transparent and reproducible tool for analyzing neuro-spatial properties in educational situations. While the approach is illustrated in a single case study, it is intended to facilitate future application and modification across different educational environments.

Figure 4 depicts the sequential development process, showing the passage from theoretical synthesis and indicator generation to framework operationalization and empirical application.

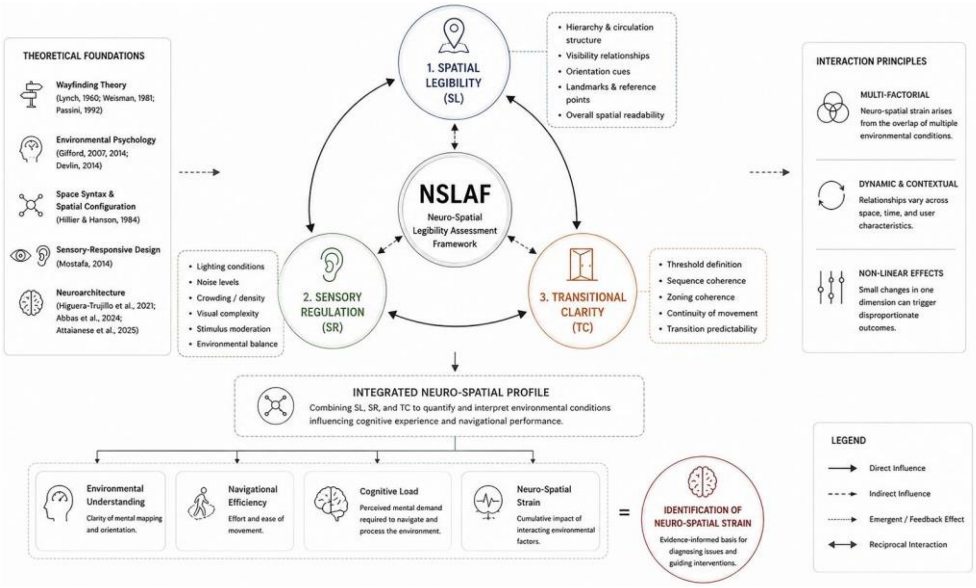

Figure 4. Development Process of the Neuro-Spatial Legibility Assessment Framework (NSLAF).

Sequential workflow illustrating the development of NSLAF through four stages: (1) theoretical synthesis, (2) indicator identification and classification, (3) framework operationalization, and (4) empirical application using architectural analysis, structured field observations, sensory environment assessment, a pilot student perception survey, and qualitative benchmarking with Caudwell International children's center.

2.4.2 NSLAF Assessment Indicators

The three assessment dimensions of NSLAF are operationalized through a well-organized set of qualitative indicators based on the principles of spatial cognition, wayfinding, environmental psychology, sensory-responsive design, and neuro-architecture (Lynch, 1960; Weisman, 1981; Passini, 1992; Mostafa, 2014; Higuera-Trujillo et al., 2021; Abbas et al., 2024). The indicators are the translation of the theoretical concepts in measurable architectural qualities that may be systematically recorded during the environmental evaluation. Instead of assessing architectural characteristics individually, NSLAF considers the combination of Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC) to define neuro-spatial circumstances in educational settings. Table 1 presents the assessment indicators and sources of evidence for each item.

Table 1. NSLAF Dimensions, Assessment Indicators, and Evidence Sources.

NSLAF Dimension	Assessment Indicators	Evidence Source
Spatial Legibility	Spatial hierarchy, visibility, corridor differentiation, landmark distribution, orientation cues, spatial readability, circulation clarity	Architectural plans, circulation mapping, structured field observations
Sensory Regulation	Acoustic exposure, lighting consistency, visual complexity, crowd density, environmental distractions, sensory balance	Qualitative environmental observations
Transitional Clarity	Threshold definition, zoning continuity, movement sequencing, spatial transitions, circulation continuity, predictability of movement	Structured observations, circulation analysis, architectural documentation

Table 1 demonstrates how each assessment dimension is operationalized through observable architectural characteristics and the corresponding evidence sources used during the assessment. Together, these indicators establish the analytical basis for interpreting neuro-spatial characteristics within existing educational environments.

To promote consistency, qualitative performance criteria were defined for each assessment dimension. Rather than generating numerical scores, NSLAF classifies environmental conditions according to the observed quality, consistency, and interaction of architectural characteristics. The qualitative interpretation criteria are presented in Table 2.

Table 2. Qualitative Interpretation Criteria for the Neuro-Spatial Legibility Assessment Framework (NSLAF).

Qualitative Performance Criteria for the Neuro-Spatial Legibility Assessment Framework (NSLAF)			
Dimension	**Low Performance**	**Moderate Performance**	**High Performance**
Spatial Legibility (SL)	Repetitive spatial organization, weak hierarchy, limited visibility, absence of landmarks, poor orientation cues	Partial hierarchy with some recognizable orientation cues and moderate environmental differentiation	Clear spatial hierarchy, strong visual landmarks, intuitive circulation, and easily interpretable spatial organization
Sensory Regulation (SR)	Excessive noise, visual clutter, crowding, inconsistent lighting, and uncontrolled sensory stimuli	Moderate sensory stimulation with occasional environmental distractions	Balanced sensory conditions, controlled environmental stimuli, consistent lighting, and reduced environmental distractions
Transitional Clarity (TC)	Abrupt transitions, fragmented zoning, unclear thresholds, discontinuous circulation sequences	Generally coherent transitions with minor inconsistencies between adjacent spaces	Clearly articulated thresholds, continuous spatial sequencing, coherent zoning, and predictable movement pathways

NSLAF integrates findings across Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC) to produce a unified neuro-spatial profile for each place examined, rather than treating each dimension in isolation. Higher neuro-spatial load is attributed to contexts with pervasive deficits along different axes. Perceived contexts with explicit spatial organization, balanced sensory conditions, and coherent movement sequences are more facilitative of environmental understanding and less cognitively demanding. This integrated perspective is consistent with modern neuroarchitectural research, which highlights that cognitive experience is the result of the interaction of various environmental variables, rather than separate design features (Higuera-Trujillo et al., 2021; Abbas et al., 2024).

2.5 Data Collection and Analysis

Data collection was based on a multimethod qualitative design combining architectural study, structured field observations, sensory environment evaluation, a prototype student impression survey, and qualitative benchmarking with Caudwell International children’s center. This design was informed by recognized qualitative case study and architectural research procedures, which emphasize the usefulness of synthesizing numerous sources of information to explore complex environmental phenomena (Groat & Wang, 2013; Yin, 2018; Creswell & Poth, 2018). Methodological triangulation was used to synthesise these complementary data sources to enhance the credibility and depth of the environmental assessment (Denzin, 1978; Patton, 2015).

The integration of architectural documentation, field observations, and user impressions is also consistent with concepts of post-occupancy evaluation, which support the use of different evidence sources to assess building performance (Preiser et al., 1988).

Floor plans and site layouts, as part of the architectural documentation, were studied to understand circulation networks, spatial hierarchy, visibility linkages, orientation signals, and movement sequences. Structured field observations were later done utilizing standardized NSLAF recording sheets to document movement patterns, congestion points, directional decisions, circulation conflicts, and recurring navigation-related behaviors during ordinary school activities.

Sensory environment assessments characterized systematic auditory exposure, illumination consistency, visual complexity, crowd density, and features of transitional areas. Observations were used to rate Sensory Regulation (SR) and Transitional Clarity (TC). To support the environmental assessment, a pilot student perception survey (n = 30) gathered users' impressions of navigational difficulty, environmental predictability, perceived cognitive effort, and neuro-spatial strain. Descriptive interpretation of survey responses were made in conjunction with architectural and observational findings and not as psychological or clinical outcome measures.

Following data collection, all information was grouped according to the three NSLAF assessment dimensions: Spatial Legibility (SL), Sensory Regulation (SR), and Transitional Clarity (TC). Each dataset was first examined independently, then combined using a systematic qualitative coding procedure to identify patterns of convergence and divergence across the architectural, observational, sensory, and perceptual evidence.

Instead of generating numerical scores, the NSLAF adopts qualitative interpretation criteria to describe the environment based on the observed quality, consistency, and interaction of the evaluation indicators. Each examined location was rated as displaying Low, Moderate, or High performance for each assessment dimension using the criteria described in Table 2.

Finally, the three elements of assessment were combined to produce an integrated neuro-spatial profile for each investigated area. Areas with simultaneous deficits in multiple dimensions were interpreted as being related to higher neuro-spatial strain, while environments with clear spatial organization, balanced sensory conditions, and coherent movement sequences were interpreted as supporting lower perceived cognitive demand and better environmental comprehension.

Throughout the investigation triangulation of methods was the key analytical strategy. The consistency of the observed environmental patterns was analyzed through a careful comparison of findings generated from architectural analysis, field observations, sensory evaluations, the pilot perception survey, and qualitative benchmarking. This constant comparison decreased reliance on any single source of evidence and enhanced the interpretive credibility of the judgment (Denzin, 1978; Patton, 2015).

To ensure scientific consistency and transparency, consistent observation methods, evaluation indicators and qualitative interpretation criteria were applied throughout the study. The same analytical methodology was developed in both the case-study school and the reference educational environment, allowing for consistent implementation of the NSLAF protocol in both settings.

Table 3 presents an overview of the data sources, analytical objectives, and the evaluation results.

Table 3. Summary of Data Sources, Analytical Objectives, and Assessment Outputs

Data Source	Analytical Objective	Assessment Output
Architectural analysis	Examine spatial organization, circulation hierarchy, visibility relationships, and orientation cues	Spatial configuration maps and Spatial Legibility (SL) assessment
Structured field observations	Document movement patterns, directional decisions, congestion points, and circulation conflicts	Structured observational records supporting SL and TC assessment
Sensory environment assessment	Characterize acoustic exposure, lighting consistency, visual complexity, crowd density, and transitional conditions	Sensory profile supporting SR and TC assessment
Pilot student perception survey (n = 30)	Explore perceptions of navigation, environmental predictability, perceived cognitive demand, and neuro-spatial strain	Descriptive summary supporting qualitative interpretation
Qualitative benchmarking	Compare the case-study school with a reference educational environment	Contextual benchmark supporting interpretation of NSLAF findings

Summary of other sources of evidence used in the assessment are presented in Table 3. These datasets, taken together, supported the integrated evaluation of Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) to help interpret environmental conditions linked to neuro-spatial strain.

3. Results

The Neuro-Spatial Legibility Assessment Framework (NSLAF) was employed to examine the neuro-spatial characteristics of Lycée de Ben Arous through the combined assessment of Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC). The results are presented for each assessment dimension, then an integrated evaluation, data from the pilot student perception survey and qualitative benchmarking. The analysis is based on architectural documentation, organized field observations, sensory environment assessment, survey responses and comparative benchmarking.

3.1 Overview of the NSLAF Assessment

The NSLAF assessment showed distinct differences in neuro-spatial circumstances around the school campus. While the general arrangement offers uninterrupted connection among the interconnected classroom blocks, courtyards, and linear circulation corridors (Figure 5), the environmental conditions varied by differences in the spatial arrangement, sensory control, and transitional continuity.

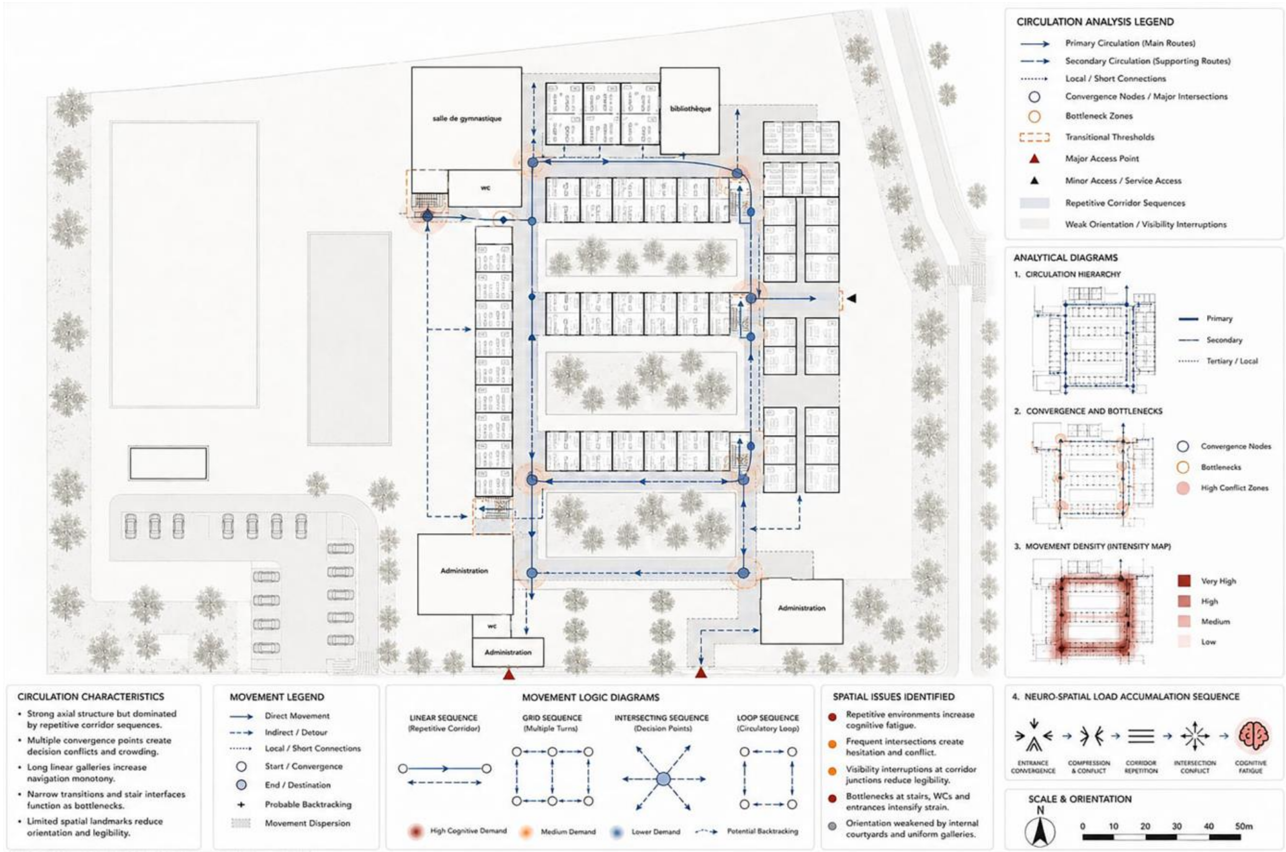

Figure 5. Overall Spatial Organization of Lycée de Ben Arous.

Architectural diagram of Lycée de Ben Arous indicating the classroom blocks, circulation corridors, courtyards, key pedestrian routes, and the observation places analyzed using the Neuro-Spatial Legibility Assessment Framework (NSLAF).

Table 4 presents the assessment results. The key points of deficiency across various dimensions of assessment were the main hallway, staircase node and main entrance and the highest levels of neuro-spatial strain were recorded at these points. In contrast, the administration area and Courtyard A had better Spatial Legibility, reduced sensory demands, and clearer sequences of movement, resulting in lower levels of neuro-spatial strain. The classroom wing, secondary corridor and outdoor transition spaces showed intermediate environmental profiles, representing localized spatial and sensory limitations.

Table 4. Qualitative NSLAF Assessment of the Principal School Spaces

Qualitative NSLAF Assessment of the Principal School Spaces				
Space	Spatial Legibility	Sensory Regulation	Transitional Clarity	Integrated Neuro-Spatial Profile
Main Entrance	Moderate	High	Moderate	High
Administration	High	Low	High	Low

Main Corridor	Low	Moderate	Low	High
Courtyard A	High	Low	High	Low
Classroom Wing	Moderate	Moderate	Moderate	Moderate
Staircase Node	Low	High	Low	High
Secondary Corridor	Moderate	Moderate	Low	Moderate
Outdoor Transition	High	Moderate	Moderate	Moderate

Overall, the results suggest that differences in neuro-spatial conditions were more strongly related to differences in Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) than to the functional usage of individual locations.

3.2 Spatial Legibility (SL)

The Spatial Legibility (SL) evaluation revealed considerable variances in environmental readability across the school site (Figure 6). The lowest levels of spatial legibility were found in the central circulation spine, at major corridor junctions and within the repetitive classroom corridors, where a lack of visual distinction, fragmented views, a weak circulation hierarchy and the repetitive architectural morphology made the environment less distinctive.

Open courtyards were essential spatial reference points but their usefulness for orientation depended on the architectural context in which they had been located. The courtyards, visually identical to classroom blocks, afforded less orientation signals than those associated with more varied spatial layouts.

Across the campus, lower Spatial Legibility was always linked with four reoccurring architectural features:

- repeating hallway geometry
- poor distinction of landmarks
- visibility links disrupted
- hierarchy of feeble circulation.

Conversely, the sites that had clearer spatial organization, stronger visual connectedness, recognized landmarks, and more coherent circulation patterns showed higher levels of Spatial Legibility.

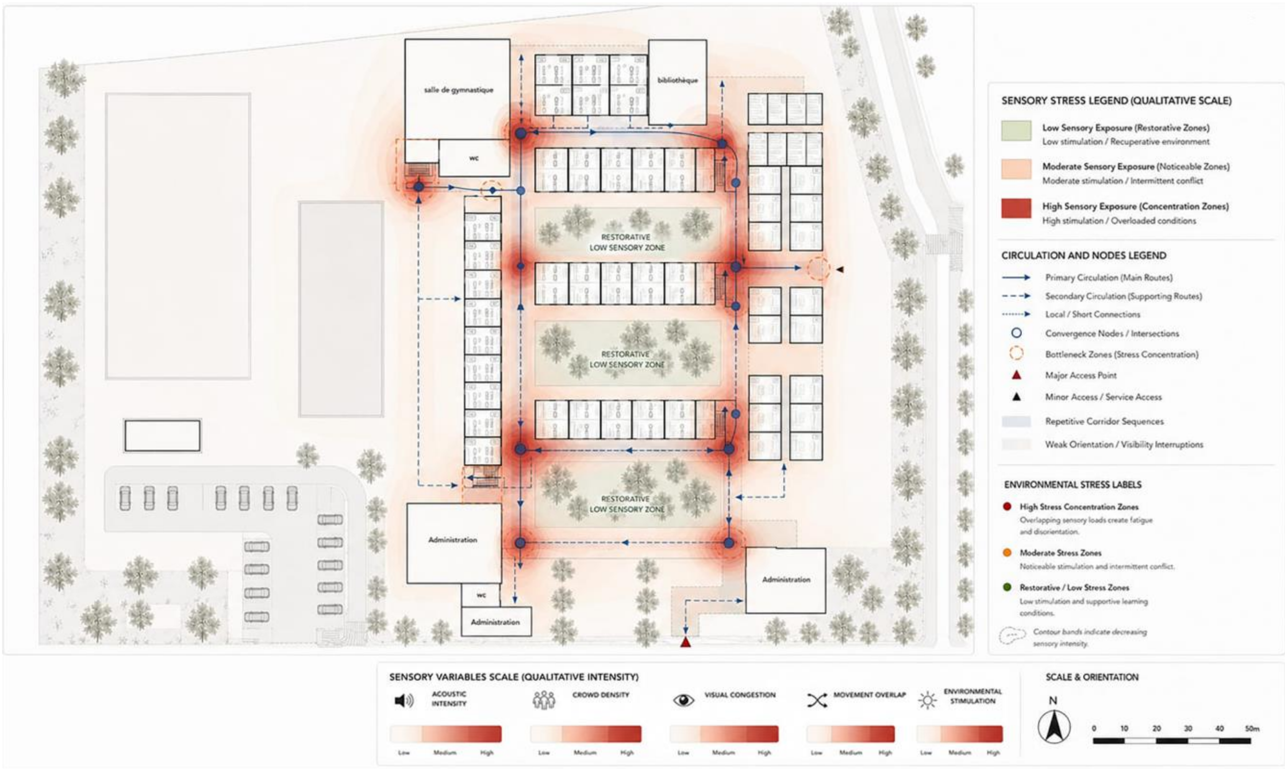

Figure 6. Spatial Legibility (SL) Assessment of Lycée de Ben Arous.

Qualitative evaluation of the spatial distribution of the Spatial Legibility (SL). Areas are rated as having high, moderate, or poor environmental legibility based on circulation hierarchy, visibility linkages, landmark distinction, and orientation signals.

3.3 Sensory Regulation (SR)

The Sensory Regulation (SR) assessment showed a considerable geographical difference in environmental stimulation across the campus (Figure 7). At the main entrance, primary circulation intersections and high-density movement corridors, the highest levels of sensory stimulation were concentrated, with increased acoustic exposure, visual complexity, pedestrian density and continuous movement occurring simultaneously.

The administration zone, internal courtyards and the zone around Mourouj park were less stimulated, with more balanced environmental conditions. Also, near the southern border of the campus which is on Avenue Mohamed V, a higher sensory exposure was observed, showing the effect of the automobile traffic and pedestrian activities in the adjacent area.

Transient elevations in sensory stimulation were seen during class transitions, especially in courtyards and along the main circulation paths. These swings, however, were localized and not across the board on campus.

In summary, high levels of sensory stimulation were seen in the busiest circulation areas and along the southern site boundary, whereas locations with low pedestrian traffic often had more regulated sensory conditions.

Figure 7. Sensory Regulation (SR) Assessment of Lycée de Ben Arous.

Qualitative assessment of spatial distribution of Sensory Regulation (SR). Areas are categorized by the relative levels of environmental stimulation based on factors such as acoustic exposure, visual complexity, illumination consistency, crowd density, and surrounding environmental variables.

3.4 Transitional Clarity (TC)

The Transitional Clarity (TC) assessment showed significant variation in continuity and predictability of movement sequences across the campus (Figure 8). The lowest levels of Transitional Clarity were recorded at indoor-outdoor interfaces, corridor bifurcations and building entrances, where insufficient threshold definition, changes in circulation direction and fragmented movement sequences diminished spatial continuity.

Conversely, the classroom wings displayed sharper transitions between neighbouring areas, better organised circulation flows and a higher degree of coherence across functional zones.

Reduced Transitional Clarity was consistently connected with three recurring architectural elements across the campus:

- Weak threshold definition
- Broken sequences of movement
- Disjoint zoning of space.

On the other hand, areas with well-articulated thresholds, cohesive spatial sequencing, and predictable movement patterns showed higher levels of Transitional Clarity.

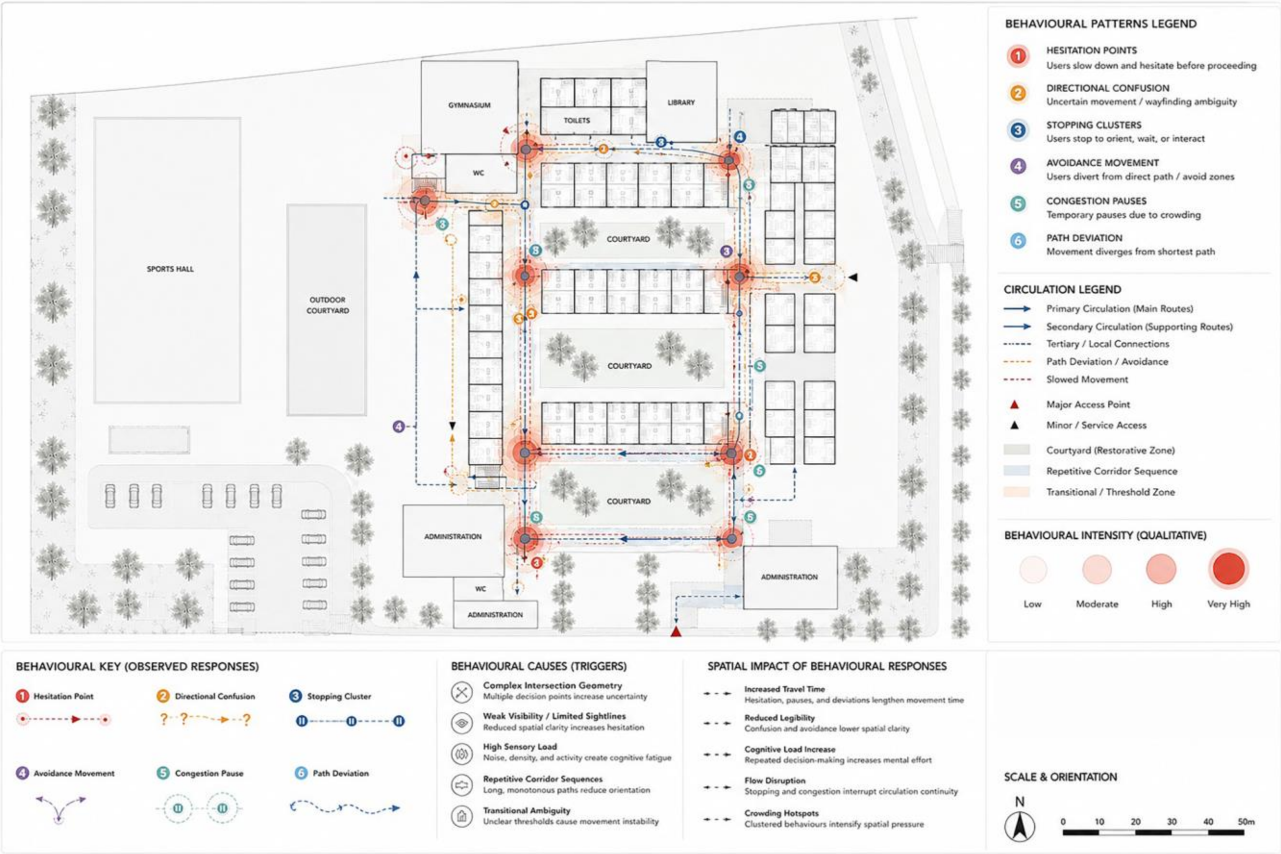

Figure 8. Transitional Clarity (TC) Assessment of Lycée de Ben Arous.

Qualitative evaluation of the spatial distribution of the Transitional Clarity (TC). Areas are characterized as threshold definition, zoning continuity, sequence of movement and predictability of spatial transition.

3.5 Integrated NSLAF Assessment

The integrated NSLAF assessment combines Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) to describe the geographical distribution of neuro-spatial strain in Lycée de Ben Arous (Figure 9).

The neuro-spatial strain was not evenly distributed around the university, rather clustered. Maximum levels were found where there were junctions of principal circulations, extended stretches of corridors, transitions at entrances, and large pedestrian convergence zones, where inadequacies in two or more dimensions of the NSLAF overlapped.

Conversely, the administration area, classroom wings, and interior courtyards showed lower degrees of neuro-spatial strain, which can be attributed to clearer spatial organization, more balanced sensory conditions, and more continuity of movement sequences.

Overall, the integrated assessment suggests that sites with concurrent impairments in Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) are consistently linked to the highest levels of neuro-spatial strain.

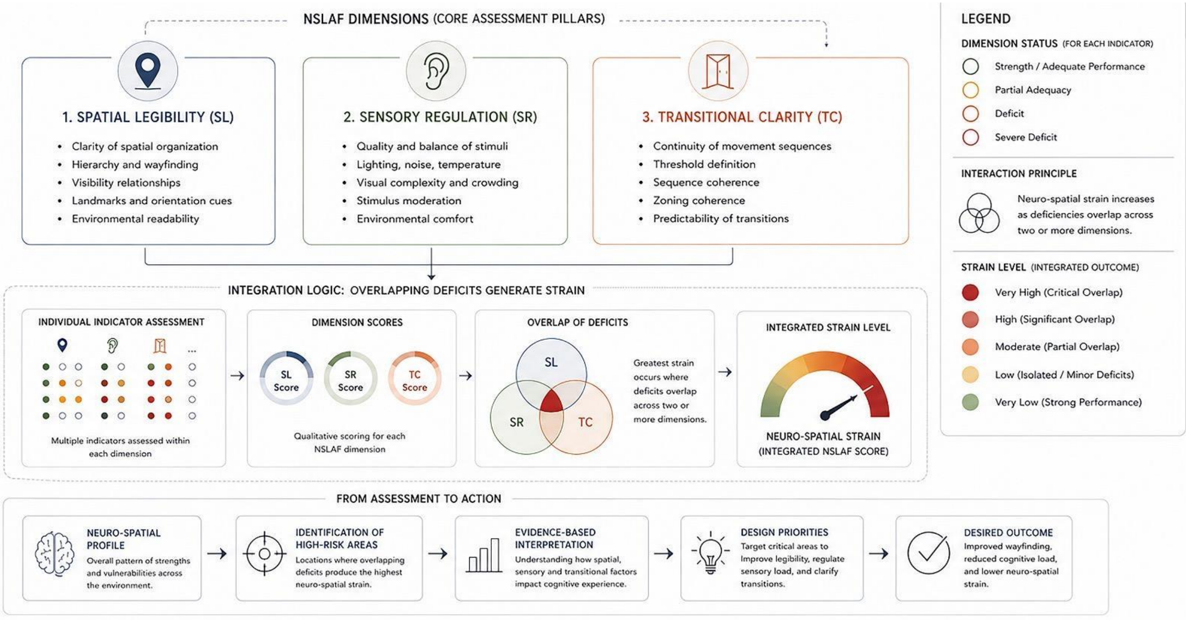

Figure 9. Integrated Neuro-Spatial Strain Assessment Using NSLAF.

Composite qualitative map of neuro-spatial strain distribution based on integrated assessment of Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC). Greater neuro-spatial strain is associated with areas with deficits overlapping across various measures of assessment.

3.6 Pilot Student Perception Survey

To support the environmental evaluation, a pilot perception survey involving 30 students (n = 30) was undertaken to explore participants' impressions of navigational difficulties, environmental predictability, and cognitive demand during normal mobility within the school.

Participants assessed moderate navigational difficulty overall with the most problematic locations being corridor intersections, entrance areas and key circulation nodes. Increased cognitive effort was also recorded during moments of heavy pedestrian activity, notably along the primary circulation corridors and within entrance zones.

As shown in Table 5, these reported experiences were very consistent with the locations identified by the NSLAF assessment as having a high neuro-spatial strain.

Table 5. Summary of the Pilot Student Perception Survey and Correspondence with the NSLAF Assessment

Survey Theme	Observed User Response	Corresponding NSLAF Dimension(s)
Navigational difficulty	Highest at corridor intersections and circulation nodes	Spatial Legibility (SL), Transitional Clarity (TC)
Environmental predictability	Reduced within repetitive circulation sequences and entrance transitions	Transitional Clarity (TC)
Mental workload	Increased during periods of high pedestrian activity	Sensory Regulation (SR)
Overall spatial experience	Greater navigational effort reported in areas classified as high neuro-spatial strain	Integrated NSLAF Assessment

The pilot survey was not meant as a statistical validation but as an additional source of evidence. However, the internal consistency of the NSLAF framework is supported by the congruence of participants' reported experiences with the qualitative environmental evaluation

3.7 Comparative Benchmark Analysis

Figure 10 shows the qualitative application of the framework to the caudwell international children's center in order to test the applicability of the framework.

Compared with Lycée de Ben Arous, the center displayed greater levels of Spatial Legibility (SL) and Transitional Clarity (TC), combined with more balanced Sensory Regulation (SR). The primary circulation routes were better distinguished, architectural features were more distinctive, and the sequence of movements was more continuous.

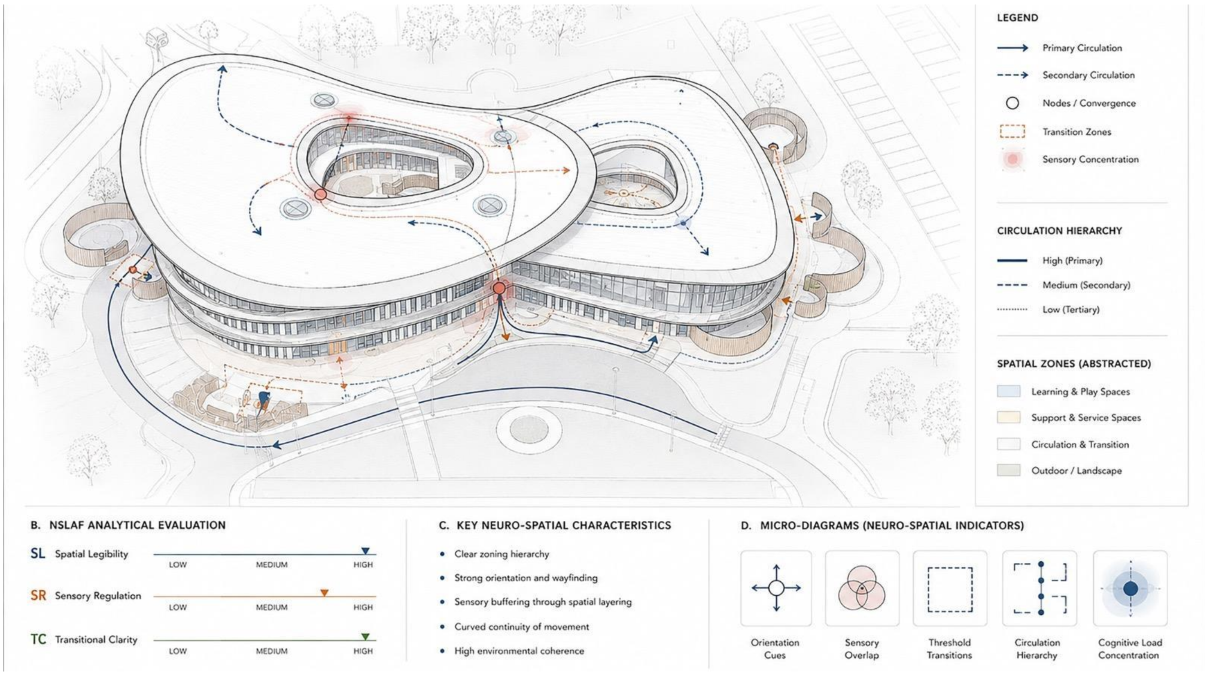

Figure 10. Comparative Benchmark Assessment of Educational Environments.

Comparative qualitative assessment of Lycée de Ben Arous and the reference secondary school according to the three NSLAF dimensions. The comparison shows differences in spatial structure, sensory circumstances, transitional continuity and subsequent distribution of neuro-spatial strain.

In contrast, Lycée de Ben Arous exhibited less repetitive circulatory geometry, a weaker spatial hierarchy, and more variety in sensory conditions, indicative of a wider distribution of neuro-spatial strain.

The same protocol assessment was used in all studies and it showed the same implementation of NSLAF in different educational contexts.

3.8 Summary of the Main Findings

The application of the Neuro-Spatial Legibility Assessment Framework (NSLAF) showed clear spatial variability in neuro-spatial conditions across Lycée de Ben Arous. Increased neuro-spatial strain was focused in entrance regions, major circulation corridors, stair nodes and major circulation intersections where decreases in Spatial Legibility (SL), increases in sensory demands and limited Transitional Clarity (TC) all occurred simultaneously.

These observations were reinforced by the pilot student perception survey, in which participants reported higher navigational difficulties and cognitive demand in areas designated by NSLAF as areas of heightened neuro-spatial strain. Likewise, the comparative benchmark evaluation showed that the Caudwell international children’s center, with a more distinct circulation hierarchy, greater environmental differentiation and more consistent movement sequences, experienced less neuro-spatial stress than the case-study school.

A consolidated overview of the principal findings is presented in **Table 6**.

Table 6. Summary of the NSLAF Assessment Results

Summary of the NSLAF Assessment Results			
NSLAF Dimension	**Observed Spatial Characteristics**	**Primary Locations**	**Key Observation**
Spatial Legibility (SL)	Repetitive corridor geometry, limited landmarks, weak circulation hierarchy, fragmented visibility	Corridor intersections, classroom corridors, circulation nodes	Reduced environmental readability and increased navigational uncertainty
Transitional Clarity (TC)	Weak threshold definition, discontinuous spatial sequencing	Building entrances, corridor bifurcations, courtyard interfaces	Reduced environmental predictability
Sensory Regulation (SR)	Elevated noise, visual complexity, crowd density	Main entrance, circulation corridors, high-density intersections	Increased sensory stimulation
Integrated NSLAF Assessment	Concurrent deficiencies across SL, SR, and TC	Entrance zones, circulation convergence points, repetitive movement sequences	Highest neuro-spatial strain
Pilot Student Perception Survey (n = 30)	Greater navigational difficulty and cognitive demand	Locations identified above	Findings consistent with the qualitative assessment
Comparative Benchmark	Stronger spatial hierarchy, clearer landmarks, more coherent transitions	Caudwell international children's center	Lower overall neuro-spatial strain than the case-study school

Table 6 summarizes the main conclusions from the architectural study, the structured field observations, the sensory environment assessment, the pilot student perception survey and the comparative benchmarking.

Collectively, the data suggest that neuro-spatial strain is related to the combined effect of spatial organization, sensory circumstances and transitional continuity rather than to individual architectural features. The results reported here are the basis of the debate that will be presented in the next section.

4. Discussion

4.1 Interpretation of Key Findings

The findings suggest that neuro-spatial conditions in educational spaces are the product of an interplay between several architectural features rather than any single spatial characteristic. The implementation of the Neuro-Spatial Legibility Assessment Framework (NSLAF) showed that regions with lower spatial legibility (SL), higher sensory regulation (SR) and limited transitional clarity (TC) always needed more navigational effort and higher perceived cognitive demand. This pattern is in line with contemporary neuroarchitectural research indicating that cognitive and emotional responses to the built environment are a result of the synergistic effect of spatial organization, sensory conditions and environmental predictability, rather than being a result of individual architectural features (Higuera-Trujillo et al., 2021; Abbas et al., 2024; Attaianese et al., 2025; Kazak & van Hoof, 2025).

Of the three assessment characteristics, Spatial Legibility emerged as the structural underpinning for effective environmental navigation. Basic research has established that obvious circulation hierarchies, identifiable landmarks, and consistent spatial organization support cognitive mapping and orientation within the environment (Lynch, 1960; Weisman, 1981). Wayfinding research similarly suggests that visible circulation systems minimize navigational uncertainty and facilitate more intuitive mobility (Passini, 1992). Consistent with this, the present assessment observed that places with consistent circulation patterns and greater environmental differentiation experienced lower levels of neuro-spatial strain.

But the results also imply that spatial structure alone cannot explain users' experiences of the environment. Some sites with reasonably coherent circulatory systems nonetheless needed additional cognitive work when coupled with high levels of sensory input or fuzzy spatial boundaries. This implies that Sensory Regulation and Transitional Clarity are not independent environmental variables, but rather affect the perception and experience of spatial organization. As a result, the interaction between these dimensions seems to be more important than any individual architectural feature.

Overall, our results are consistent with a systems perspective on educational environments where spatial configuration, sensory circumstances, and transitional sequences are conceived as an integrated cognitive-spatial experience. This is rooted in previous studies that have largely treated navigation, sensory experience, or environmental cognition as isolated fields of analysis (Lynch, 1960; Weisman, 1981; Passini, 1992; Higuera-Trujillo et al., 2021). The integration of these complementary dimensions into a single qualitative methodology enables NSLAF to provide a practical tool to evaluate neuro-spatial strain in existing educational environments through a neuroarchitectural lens (Abbas et al., 2024; Attaianese et al., 2025; Kazak & van Hoof, 2025).

4.2 Comparison with Previous Studies

4.2.1 Spatial Legibility, Environmental Cognition, and Wayfinding

The relationship between Spatial Legibility (SL) and navigational performance found in the present study aligns with established theories of environmental cognition and wayfinding. Basic studies indicated that easy physical organization, identifiable landmarks, and consistent circulation systems support cognitive mapping, environmental orientation, and effective wayfinding (Lynch, 1960; Weisman, 1981; Passini, 1992). Further research demonstrated that environmental cues, signage and spatial configuration influence users' capacity to perceive and navigate complex situations (O'Neill, 1991; Devlin, 2014). In a similar vein, Space Syntax investigations underscore the significance of spatial hierarchy and configurational links in influencing movement patterns and accessibility (Hillier & Hanson, 1984).

The present findings corroborate these recognized ideas, while extending them in an essential way. While the main structural basis for orientation was found to be spatial legibility, the evaluation also suggested that navigational performance was also dependent on the quality of sensory conditions and the continuity of spatial transitions. Effective navigation was not only a matter of configurational clarity, but also of the wider environmental context. This perspective is in line with recent work that stresses the multidimensionality of environmental cognition and the importance of integrated spatial experience for navigation and orientation support (Erkan, 2024).

4.2.2 Neuro-architecture and Cognitive-Emotional Processing

These findings are consistent with recent neuroarchitectural studies that suggest that cognitive and emotional reactions to the built environment are the result of the interaction of spatial organization, sensory stimulation, and environmental perception, rather than individual architectural features (Higuera-Trujillo et al., 2021; Abbas et al., 2024; Attaianese et al., 2025; Kazak & van Hoof, 2025). Similarly, research in evidence-based and healing environments has indicated the role of architectural organization in supporting users' cognitive performance, emotional well-being, and overall environmental experience, mediated by the interaction of multiple environmental factors rather than any single design element (Sternberg, 2009).

In the present investigation, the sites identified by NSLAF as having a greater neuro-spatial strain, showed overlapping deficits in the factors of Spatial Legibility, Sensory Regulation and Transitional Clarity. This convergence bolsters the view of educational settings as cognitive-spatial systems rather than as a set of isolated contextual features.

Unlike many neuroarchitectural studies that use laboratory-based methods, such as electroencephalography (EEG), eye-tracking, or immersive virtual reality simulations (Erkan, 2019; Azzazy et al., 2021; Tawil & Kühn, 2024), the NSLAF offers a qualitative observational approach that can be used in current educational contexts through the use of traditional architectural documentation, structured observations, and environmental evaluation. This boosts the practical usability of this framework, particularly for schools with limited access to specialized neuroscientific equipment or experimental facilities.

4.2.3 Methodological Contribution Relative to Existing Assessment Frameworks

NSLAF supplements the existing architectural assessment methodologies by combining the best of them in one qualitative framework. Space Syntax mainly focuses on spatial configuration and movement potential through configurational analysis (Hillier & Hanson, 1984) while Post-Occupancy Evaluation (POE) examines the occupants' perception of environmental performance after the building occupation (Preiser et al., 1988). Likewise, wayfinding research considers navigation, direction, and readability of the environment (Passini, 1992), while sensory-responsive design frameworks study the impact of stimuli in the environment on users' comfort, perception, and behavior (Mostafa, 2014; Higuera-Trujillo et al., 2021).

NSLAF does not replace these methodologies but incorporates their complimentary viewpoints through the combined assessment of Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC). This integrated structure enables the evaluation of educational environments as cognitive-spatial systems which simultaneously consider spatial organization, sensory circumstances and movement continuity (Abbas et al., 2024; Attaianese et al., 2025).

Therefore, the main contribution of NSLAF from the methodological point of view is not to propose new variables but to operationalize old neuroarchitectural notions in a consistent and reproducible assessment approach. NSLAF constitutes an improvement over existing assessment methods in combining configurational, sensory and transitional features into one qualitative framework; it is however possible to use NSLAF to examine existing educational settings.

Taken together, these comparisons suggest that NSLAF offers a structured way to convert existing neuroarchitectural information into the evidence-based evaluation and enhancement of current educational environments.

4.3 Strengths and Limitations

Several methodological aspects of the present study support the credibility and application of the Neuro-Spatial Legibility Assessment Framework (NSLAF). Firstly, the framework organizes well-known ideas from neuro-architecture, environmental psychology, and wayfinding research into a qualitative evaluation process for existing educational environments (Groat & Wang, 2013; Creswell & Poth, 2018). By combining Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) in one examination, NSLAF provides a more holistic view compared to techniques that deal with these elements individually.

A second strength is the application of methodological triangulation, consisting of architectural analysis, organized field observations, qualitative sensory assessment, a pilot student perception survey, and comparative benchmarking (Denzin, 1978; Patton, 2015). These complementary kinds of information together made the conclusions more credible and meant we could not rely on just one method. Furthermore, the use of standardized assessment indicators, observation procedures and systematic documentation increases the transparency and reproducibility of the framework (Preiser et al., 1988).

A number of constraints should also be mentioned. The study was limited to one qualitative case study. The pilot survey on students' perceptions was applied to a somewhat small sample (n=30). Therefore, the findings should be considered exploratory and context-specific and not statistically generalizable.

Moreover, NSLAF is designed as a qualitative diagnostic framework rather than a predictive or causal model. Although it points to environmental variables that are associated with increased navigation-related cognitive demands, it does not show causal links between architectural traits and psychological effects. Further quantitative and experimental work will be needed to address these links.

Finally, the qualitative assessment necessarily incorporates professional judgement, notwithstanding the use of defined criteria and methodical triangulation. Standardized scoring processes, formal inter-rater reliability testing, and deployment across a wider range of educational settings would further bolster methodological consistency and external applicability and would enhance future refining of the framework.

5. Conclusion

Summary of Key Findings

In this study, the Neuro-Spatial Legibility Assessment Framework (NSLAF), as a qualitative diagnosis method, was developed and used to assess the impact of architectural organization on neuro-spatial strain in educational environments. NSLAF fills a methodological gap in neuro-architecture by integrating the concepts of Spatial Legibility (SL), Sensory Regulation (SR) and Transitional Clarity (TC) into a holistic framework to assess existing school environments.

The case of Lycée de Ben Arous applying the framework demonstrated that neuro-spatial strain is caused by the interaction of multiple environmental characteristics, and not by isolated architectural deficiencies. Locations with recurrent circulation patterns, little environmental distinctiveness, fragmented transitions, and high sensory stimulation were consistently associated with locations demanding more navigational effort and greater perceived cognitive effort. These results support the notion that educational environments are structured as integrated cognitive-spatial systems in which the architectural organization impacts environmental understanding and everyday navigation.

More generally, the study illustrates that the assessment of the spatial structure, sensory circumstances and transitional continuity as complementing aspects results in a more complete knowledge of neuro-spatial performance than the assessment of these qualities in isolation.

Implications of the Findings

The main contribution of this research is the establishment of a systematic and adaptable assessment approach that converts the neuroarchitectural theory into practical architectural evaluation. Instead of analysing spatial arrangement, environmental performance or user perception separately, NSLAF merges these complimentary viewpoints into a unified qualitative approach for the identification of neuro-spatial difficulties in existing educational environments.

Practically, the framework offers architects, planners, school administrators and policy makers an evidence-informed tool to identify areas of elevated neuro-spatial strain and prioritize focused improvements. The framework is especially relevant to educational facilities that often have limited resources to undertake major redevelopment but can improve the readability of the environment through strategies such as improving circulation hierarchy, strengthening environmental cues, clarifying spatial transitions and moderating sensory stimulation.

Limitations of the Study

A few limitations should be mentioned. First, the study is based on a single qualitative case study and is complemented with a pilot perception survey of thirty participants and so the findings should be considered as exploratory and are not statistically generalizable. Second, NSLAF is an interpretative diagnostic framework and does not infer causal links between architectural traits and cognitive or psychological results. Finally, despite the use of standardized markers to promote comparability of assessments, additional refinement is necessary to build quantitative scoring processes and officially measure inter-rater reliability.

Recommendations for Future Research

Application of this framework to various education settings with different architectural, cultural, and climatic contexts is suggested to further study the transferability of NSLAF and improve its assessment standards. Methodological development should focus on standard scoring techniques, reliability testing, and mixed-method validation of qualitative evaluation and quantitative analytics.

Integrating NSLAF with digital spatial analysis tools such as Space Syntax, GIS and Building Information Modeling (BIM) and objective neuroarchitectural methods like eye-tracking, electroencephalography (EEG), wearable physiological sensors, behavioral mapping and virtual reality, could lead to a more comprehensive study of the relationships between environmental features and cognitive, behavioural and physiological responses.

In sum, the present study suggests that the architectural structure of educational environments should be considered not only as a functional attribute, but also as a crucial driver of cognitive experience. NSLAF provides a reproducible framework for assessing Spatial Legibility, Sensory Regulation, and Transitional Clarity in existing schools, laying the methodological groundwork for future neuroarchitectural research, and facilitating evidence-informed design and improvement of more legible, inclusive, and cognitively supportive educational environments.

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Conflicts of Interest
The author(s) declare(s) no conflicts of interest.

Data availability statement
The original contributions presented in this study are included within the article and its supplementary materials. Additional analytical materials, including architectural mapping outputs, observational records, and diagrammatic documentation supporting the findings of this study, are available from the corresponding author upon reasonable request.

Institutional Review Board Statement

Not applicable.

This study primarily involved architectural, spatial, and environmental analyses supported by a non-invasive pilot perception survey. No clinical procedures, experimental interventions or collection of sensitive personal information were included in the study. Participation in the pilot survey was voluntary and anonymous and respondents were informed of the purpose of the study before their participation. The study was conducted according to the ethical principles of the Declaration of Helsinki . All information collected was kept confidential, and was used only for academic research purposes.

CRediT author statement

Conceptualization: Author

Methodology: Author

Software: Author

Validation: Author

Formal analysis: Author

Investigation: Author

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Data curation: Author

Visualization: Author

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