

Evidence-based implications for school architecture: spatial layout and teachers' perceived sense of school control

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Abstract

Purpose – The role of architectural design in shaping educational environments has received increasing attention in recent years, shifting the focus from purely functional spaces to the relational dynamics between spatial configuration, pedagogical practice, users' perspectives and user experience. While research on school architecture has widely emphasized the interplay between spatial form and student learning, empirical studies that connect spatial layout with teachers' perceptions remain limited. This study contributes to this growing discourse by examining how school layouts influence teachers' perceived sense of school control, namely teachers' belief about their ability to supervise, support and engage with students in school spaces.

Design/methodology/approach – Using a mixed-methods approach, this study integrates space syntax and morphological analysis with teacher surveys from five lower secondary schools in Cyprus.

Findings – The developed statistical models explain between 42 and 58% of the variance in teachers' responses. The most robust model accounts for 58%, highlighting the combined influence of a school's axial control and plot coverage ratio in supporting teacher's perceived control. The findings underscore the role of spatial design in facilitating teachers' perceived sense of control. Specifically, school layouts that offer greater visibility and movement contribute to a stronger sense of control, while excessive school exposure to the street network correlates with increased challenges in maintaining order.

Originality/value – The results reinforce the critical role of architectural design in shaping safe, functional and effective educational environments, providing a research-based framework to guide school planning and policy decisions.

Keywords School architecture, School control, Space syntax, Evidence-based design, School safety

Paper type Research article

1. Introduction

Schools are more than just places of instruction; they are institutional environments that shape behavior and interactions among students, teachers and staff. This understanding has driven significant investment in school construction across the globe in the twenty-first century, reflecting a widespread belief in the transformative power of educational architecture (Chiles, 2015). More importantly, spatial experiences within schools are not merely functional but also

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perceptual: the way individuals interpret, navigate and engage with their physical surroundings deeply influences how they learn, teach, interact, supervise and participate in school life.

While considerable attention has been given to how school architecture influences students' behaviors, interactions, perceptions and learning outcomes (Patel *et al.*, 2022; Kepez and Ust, 2022; Türel and Gür, 2019), comparatively less focus has been placed on how spatial design shapes teachers' perceptions – particularly beyond the confines of the classroom. The experience of schooling extends beyond the classroom's physical boundaries, encompassing spaces that encourage presence, responsiveness and informal interactions – elements essential to effective pedagogical practice outside the traditional classroom, and which can shape how both students and teachers perceive the school environment (Kishimoto and Taguchi, 2014; Cotterell, 1984).

Among these perceptual dynamics, teachers' perceived sense of spatial control, defined not as rigid oversight, but as an ability to remain present, aware and responsive to school community challenges, has emerged as a critical factor in shaping the everyday experience of schooling. Research shows that the school layout significantly influences teachers' perceived sense of control and ability to maintain order. Circulation paths aid in visual surveillance, facilitate social interaction and help suppress negative behaviors (Bentinck *et al.*, 2020; Moore and Lackney, 1994; Moore *et al.*, 1979; Uline and Tschannen-Moran, 2008; Sailer, 2015). Similarly, the relationship between a school and its surrounding environment, such as its degree of exposure to streets and vehicular movement, is a key factor in perceptions of safety and supervision (Greenman, 1988; Moore *et al.*, 1979).

Despite these insights, existing literature lacks clarity on which specific spatial variables best support teachers' sense of control and offers no systematic framework for analyzing how design affects educators' ability to manage their environment. This study addresses this gap by asserting that spatial and social characteristics are inherently interrelated. It investigates how spatial configuration and morphological variables affect teachers' perceived ability to supervise, interact and maintain order. Specifically, it hypothesizes that certain configurations – such as higher visual prospect, reduced street exposure, and greater plot coverage – may influence perceived control by enabling visibility, encouraging informal encounters and minimizing disruptions.

The study focuses on five recently built secondary schools in Cyprus, employing spatial data, space syntax analysis and morphological assessment, correlated with teachers' perceptions. This integrated approach, it offers actionable insights for architects and policymakers. By situating perceived control as an evolving process negotiated through spatial interactions, the study captures the intricate spatial choreographies of schooling, where architecture and its occupants engage in a dynamic, reciprocal relationship. Here, authority, discipline and regulation are understood not as static impositions but as spatially mediated and continuously reinterpreted.

The findings provide evidence-based insights for architects and policymakers, offering guidance for designing schools that balance openness with supervision. Ultimately, the study contributes to discourse on spatial design in education, highlighting how architectural choices shape institutional dynamics and educational experiences. The article begins with an analysis of studies on educational aims and design guidelines in Cyprus, then examines the relationship between layout, behaviors and perceptions, reviewing key studies on space and control. Research objectives and methodology follow, leading to the survey analysis and finally a discussion of results.

2. Educational architecture, school layout and teachers' perceptions

This section examines the relationship between educational aims and contemporary school architecture guidelines in Cyprus, reflecting on how educational policy, architectural practice and socio-political change shape learning environments. It also considers how spatial

configuration influences movement, behavior, and the cognitive and emotional experience of space, ultimately shaping professional agency and daily interactions. Finally, by reviewing empirical literature, it identifies school layout aspects found to affect teachers' perceived sense of control – an important factor in managing student behavior, supporting learning, and maintaining safety and order.

2.1 Educational architecture and socio-political influences: new school buildings in Cyprus

In the early 21st century, a wave of school reconstruction in Europe and North America renewed architectural and theoretical interest in schools as a distinct building type (Mahony *et al.*, 2011). Scholars highlighted how design reflects cultural ideals, shapes educational experiences, and influences everyday interactions (Blackwell and Yaneva, 2024; Chiles, 2015). In Cyprus, these global debates intersected with a distinctive educational trajectory shaped by local cultural ideals, socio-political conditions, and global influences (Persianis, 1996; Zembylas, 2002). While the education system has often responded swiftly to societal change, school architecture has adapted more slowly, with responsiveness varying across historical periods.

The periods of British Rule and Early Independence illustrate the politicization of school architecture. During colonial rule, Neoclassical architectural elements were deliberately employed to reinforce a Greek cultural identity within educational spaces, positioning school buildings as ideological symbols of resistance. Following independence, a shift toward modernist architectural principles reflected aspirations for national rebirth and institutional autonomy. Another significant turning point occurred during the 1960 and 1970s, when minimalist aesthetics, open-air structures, and fluid spatial layouts were introduced, emphasizing openness and flexibility in educational environments. The period following the 1974 war in Cyprus further underscored the relationship between socio-economic conditions and school design, as the urgent need for new educational infrastructure led to more resource-efficient and pragmatic architectural solutions.

With Cyprus' accession to the European Union in 2004, the country embraced a vision of education aligned with European values, fostering a Euro-Cypriot educational identity. A pivotal evaluation in 2003, conducted by a committee of seven academics, culminated in the reform proposal Democratic and Human Education in a Euro-Cyprus State: Prospects for Reconstruction and Modernization (World Bank, 2014). It promoted an inclusive, student-centered approach emphasizing equality, participatory learning, and recognition of childhood and youth as distinct stages, with experiential learning and sensory engagement as core principles. These ideas shaped new national curricula in 2010–2011 and 2014–2015, redefining classrooms as “life laboratories” that integrate cognitive, physical and sensory learning. This paradigm shift sought to move beyond memorization toward hands-on, inquiry-based exploration, reflecting the system's commitment to continuous improvement and responsiveness to contemporary pedagogical theory and societal change.

Despite these structural shifts, the physical transformation of school buildings in Cyprus has lagged behind educational reforms. As Hertzberger (2008, p. 256) famously wrote “school architecture often falls behind educational innovation, because buildings tend to embody fixed routines, while pedagogy evolves dynamically”. Although design responsibility shifted to individual architects after 2000, the built environment has not kept pace with pedagogical change. Since then, the Technical Department of the Ministry of Education and Culture (TDMOEC) has issued guidelines defining spatial requirements, functional relationships, and key design considerations for new facilities (MOEC, 2022). For lower secondary schools, these include horizontal development – no more than two floors, with at least half of all functions on the ground level – covered circulation linking sections, and a clear organizational structure (Figure 1) integrating administration, classrooms, sports facilities and gathering spaces into a coherent whole.

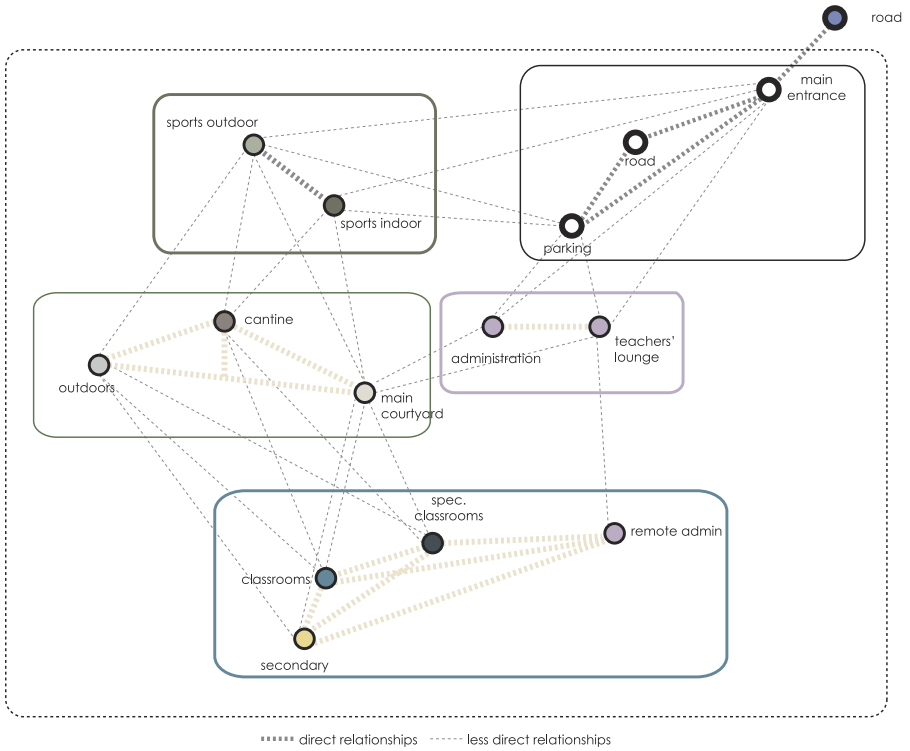


Figure 1. Visualization of the relationships between functions proposed by the design guidelines. Source: Authors' own work

Additionally, the guidelines specify the importance of school's interface with its surroundings, ensuring safe access routes, controlled pedestrian and vehicular movement, and adequate green spaces. Specific spatial requirements define the dimensions and functional relationships of key areas: general classrooms must be 55 m² to allow flexible layouts, libraries should be centrally located and easily accessible, and sports facilities positioned for community use outside school hours. Morphological guidelines remain relatively open-ended, encouraging architectural expression that reflects the institution's civic and educational role. Security considerations include fencing heights of 1.8 meters for perimeters and 4.0 meters around sports areas to prevent unauthorized access.

Lastly, MOEC (2022) guidelines also emphasize safety, accessibility, and adaptability in school architecture but do not specify how these should be spatially achieved. They largely overlook how spatial configuration shapes the perceived sense of safety and control, focusing instead on zoning, efficiency, and security measures such as fencing and controlled access, without addressing how design affects teacher oversight and student behavior. Since spatial arrangements shape disciplinary practices, issues of control should be studied as they are negotiated in everyday spatial interactions. Thus, while schools are designed to be secure and adaptable, the lack of explicit supervision considerations may limit their effectiveness in fostering environments conducive to learning and structured social engagement. Viewing schooling as a situated spatial practice offers critical insights into the interplay between architectural form and educational experience (Blackwell and Yaneva, 2024).

2.2 Spatial configuration, users' behavior and perceptions

Schools are not merely functional enclosures but are socio-spatial systems that influence behaviors and perceptions. As Hillier and Hanson (1984) posited, society organizes individuals spatially, positioning them in relation to one another with varying degrees of aggregation and separation. This spatial arrangement creates patterns of movement and encounters that can be dense or sparse within or between different groups (Hillier and Hanson, 1984). Consequently, the way spaces are structured and the manner in which people navigate and interact within them significantly impact social behaviors and society.

In that sense, a school layout can be examined as a spatial structure that evokes specific social properties that could influence behaviors and relationships between users and their perceptions. Therefore, by studying the spatial configuration of a building we can grasp both the structure of the different spaces and their cognitive character (Hillier, 2003).

For example, the ability of axial and segment line maps to be able to capture movement has been highlighted by various studies in general (Hillier, 2003; Bafna, 2003) and in school buildings (Sailer, 2015, 2018). An axial line map represents potential lines of movement through a building (Bafna, 2003), with lines running the length of corridors and connecting at intersections or classroom doorways. These connections are modeled to closely reflect reality. In open spaces, a minimal set of lines is constructed to connect, reach and cover all relevant areas of a floor plan.

Other studies have demonstrated the relationship between an increase in the control metric and the perception of spaces as either controllable or controlling. Axial control, for instance, quantifies the degree of choice each space provides for its immediate neighbors as a potential movement option (Hillier and Hanson, 1984). Each space is assigned a certain number of immediate neighbors (k), and its control value is determined by dividing 1 by k for each neighboring space and summing these values. Spaces with a control value greater than one are considered to exert strong control, while those with values less than one are deemed to be weak control spaces. A common example is a hospital corridor connected to several single-access offices. This framework helps explain how school layouts mediate supervision and control, affecting both the visibility and accessibility of different functional areas.

Further expanding this notion, Turner (2004) draws on Bentham's Panopticon as an extreme example of spatial asymmetry in control dynamics. In this architectural model, a central vantage point maintains complete visual oversight of all surrounding spaces, while peripheral areas remain highly exposed yet lacking reciprocal control. This socio-spatial arrangement highlights the relationship between the control metric and the visually dominant areas of a spatial layout. Such conditions are critical in influencing users' perceptions of a layout. By understanding how control metrics shape the perceived subservience of spaces, we can better evaluate how these configurations relate to behaviors and interactions in built environments.

This spatial understanding also provides insight into how school design facilitates or constrains movement, interaction, and visibility, offering a framework for understanding the relationship between spatial configuration, human behavior and the perceived sense of control in schools. Through this lens, school architecture is not merely a static backdrop for education, but an active agent in structuring behavior, authority and interaction within the learning environment.

2.3 Schools' spatial layout and teachers' attitudes: empirical evidence

Existing research highlights the influence of school spatial characteristics on teachers' behaviors, attitudes and professional performance (Bentinck *et al.*, 2020; Uline and Tschannen-Moran, 2008; Anderson, 1982; Brookover *et al.*, 1978; Hoy *et al.*, 1990; Tarter *et al.*, 1995). However, while substantial attention has been devoted to environmental factors such as lighting, noise and thermal comfort – each of which has been positively correlated with teacher retention (Buckley *et al.*, 2004), teaching quality (Lackney, 1999) and professional

morale (Corcoran *et al.*, 1988), fewer studies have systematically examined the impact of school layouts on teachers' perceptions of safety and control, a central concern of this study.

The role of the school's interface with the street in ensuring a sense of safety and control for teachers has also been considered in the existing body of literature. It has been argued that the school's interface with the street and vehicular movement in general is essential for ensuring a sense of safety and control (Greenman, 1988, 2005; Moore *et al.*, 1979). Specifically, a high school's interface with its surrounding streets or enhanced school porosity has been identified as a critical factor negatively influencing perceived safety and control in schools (Psathiti, 2018).

From a configurational perspective, schools with greater route selectivity and highly integrated teacher areas are perceived to facilitate smoother operational management. Conversely, schools characterized by isolated classrooms and weak circulation networks are often associated with increased flexibility in teaching but reduced control (Kishimoto and Taguchi, 2014). Schools with high spatial intelligibility, where the layout is easily understood and navigable, tend to foster stronger teacher–student interactions, improved supervision and enhanced communication among staff (Kishimoto and Taguchi, 2014; Sailer, 2018). The results suggest that teachers in such schools tend to perceive that they can lead students more carefully and attentively and that teachers can communicate well with each other.

Further research underscores the relationship between a school's spatial structure and pedagogical collaboration. Open-plan layouts, for example, have been linked to greater facilitation of interdisciplinary and collaborative teaching (Gislason, 2010), whereas fragmented or excessively complex layouts can heighten teacher anxiety and hinder behavioral monitoring (Cotterell, 1984).

The role of the spatial configuration of circulation paths (Moore and Lackney, 1994; Moore *et al.*, 1979; Lackney, 2000) has been proven to be essential for maintaining visual supervision over school grounds, allowing positive social interaction between users (Sailer, 2015, 2018) and thus minimizing negative behaviors (Moore and Lackney, 1994; Moore *et al.*, 1979) as well as for ensuring the sense of security and safety for teachers (Uline and Tschannen-Moran, 2008). Sailer (2015, 2018) also demonstrated how corridors in schools can bring people together and facilitate social encounters, as well as how the way the circulation units are connected can facilitate a degree of overlap between movement and occupation. The existence of administrative/executive spaces throughout the building in visually accessible places has also been depicted as crucial for maximizing spatial supervision and creating a practical sense of leadership (Heitor, 2005).

It is, therefore, suggested that the spatial configuration of school environments significantly relates to teachers' attitudes toward safety and control. Although much attention has been given to physical conditions like lighting and noise, configurational aspects of school design, like circulation paths, visibility and the interface with the street, play an equally critical role.

At the same time, while existing studies primarily focus on visibility, circulation and spatial connectivity, one factor that remains underexplored is the plot coverage ratio, namely the ratio of the school plot that is covered by school building, remains an underexplored factor in understanding teachers' perceived control. Schools with higher plot coverage may provide more accessible, centralized spaces, which can support teachers' perception that the layout facilitates visibility, interaction and ease of spatial oversight.

Therefore, further empirical investigation is needed to establish how the spatial layout, including visibility, circulation paths and plot coverage ratio, shapes teachers' perceptions of safety and control. A deeper understanding of these spatial dynamics will contribute to evidence-based design strategies, ensuring that school environments effectively balance functionality, safety and pedagogical needs.

3. Research design: spatial mechanisms influencing teachers' perceived sense of school control

This section outlines the theoretical and empirical foundations underpinning the hypothesis that spatial configuration influences teachers' perceptions of school control. Drawing on the existing body of literature, we propose that specific spatial characteristics – such as axial control, school interface with the street (i.e. school porosity), and plot coverage ratio – play a critical role in shaping teachers' ability to supervise and manage school environments.

We build on the hypothesis that a school's spatial configuration can significantly shape teachers' perceptions of control. According to space syntax principles, spaces with a control value greater than one are considered strong control spaces, while those below one are weak control spaces. For example, a corridor linked to multiple single-entry spaces (e.g. classrooms, offices) exemplifies a strong control environment, as its connectivity and frequent use facilitate supervision. We also hypothesize that schools with more interconnected pathways and fewer angle changes promote spatial integration, improving visibility and movement. Based on these considerations, the following hypotheses are proposed:

- H1.* Schools characterized by higher axial control will lead teachers to perceive fewer issues with school control, as teachers can supervise these schools more easily.

Building on the importance of a school's interface with the street ([Greenman, 1988](#); [Moore et al., 1979](#)), we further assume that the degree of a school's exposure to the street might also influence teachers' sense of control. Consequently, we further hypothesize that:

- H2.* Teachers in schools with lower porosity (i.e. less exposure to the street network) are more likely to perceive fewer issues with school control.
- H3.* Teachers in schools with higher axial control and lower porosity are more likely to perceive fewer issues with school control.

Building on the importance of school deployment on only two floors, as suggested by the authorities in Cyprus in the design guidelines provided by the Ministry of Education and Culture ([MOEC, 2022](#)), this study also assumes that schools with higher plot coverage ratio on the ground might have a positive impact on teachers' sense of control. Consequently, we further hypothesize that:

- H4.* Schools characterized by higher axial control and higher plot coverage ratio floor will lead teachers to perceive fewer issues with school control, as teachers can supervise these schools more easily.
- H5.* Schools characterized by lower porosity and higher plot coverage ratio will lead teachers to perceive fewer issues with school control, as teachers can supervise these schools more easily.

4. Data, research methods and case studies

This section expands on this research case studies and methodology.

4.1 Case studies: the schools' context

This study adopts a multiple case study design ([Yin, 2014](#)), focusing on five lower secondary schools (S1-S5) built after the implementation of the new educational reform in Cyprus (see [Figure 2](#)). The case studies have been anonymized in accordance with the ethical approval guidelines governing data collection and handling.

These public schools, constructed after 2000, are located in different cities (C1–C4) and were designed by various architectural practices under the supervision of the Technical Department of the Ministry of Education and Culture (MOEC). They represent the most recent


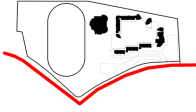

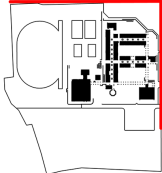

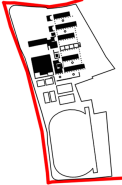

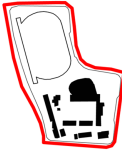
	SCHOOL POROSITY		
	 <p>School 1</p>	 <p>School 2</p>	 <p>School 5</p>
% of Intersection School Plot with Road Segment	39%	46%	46%
	 <p>School 4</p>		
% of Intersection School Plot with Road Segment	56%		
	 <p>School 3</p>		
% of Intersection School Plot with Road Segment	100%		

Figure 2. School diagrams highlighting open and closed spaces as well as street interface with the streets for all the case studies. Source: Authors' own work

wave of school construction in Cyprus and serve as a valuable dataset for assessing the relationship between spatial configuration and teachers' perceived sense of school control.

A detailed analysis of these schools was previously conducted by the first author as part of her doctoral research (Psathiti, 2021), which examined all ten secondary schools built in Cyprus after the year 2000. This date was selected as a reference point because, from that period onward, school buildings in Cyprus have been designed by individual architects following technical guidelines issued by the Ministry of Education and Culture. Moreover, this period marks the onset of significant educational reforms aimed to align pedagogical practices with contemporary educational paradigms.

According to this initial study (Psathiti, 2021), schools in Cyprus can be classified into two distinct formal typologies: (1) courtyard-based schools and (2) finger-plan schools. Courtyard-based schools are structured around a single central courtyard, which serves as the primary gathering space for students. In contrast, finger-plan schools are characterized by linear

circulation corridors with multiple smaller courtyards, resembling “fingers” extending from the main axis.

Five of the ten most recently built secondary schools in Cyprus (post-2000) were selected as case studies, representing both typological categories. Typology was not a strict analytical framework but ensured inclusion of varied configurational structures found in real-world layouts. The goal was to examine how different spatial configurations, as measured through Space Syntax and other morphological metrics, influence teachers’ perceived sense of control.

Table 1 presents key characteristics: School IDs, completion years (2002–2011) and locations (C1–C4). Student populations range from 265 to 430, with 47–63 faculty members, yielding student–teacher ratios of 5.94–7.82. Most are two-story buildings, except one single-story school. School porosity – the percentage of the building’s interface with the street – varies from 40% to 100%.

Despite differences in their urban interface (Figure 3), all schools share an open-air structure, with buildings occupying only part of the plot. Standard-sized sports facilities are consistently separated from the main building and aligned parallel to primary functions. These features reflect Cyprus’ Mediterranean climate and regulatory guidelines limiting height to two floors and requiring at least 50% of functions on the ground floor (Psathiti, 2018).

4.2 Research methodology

This study employs a twofold methodological approach to examine the relationship between spatial configuration and teachers’ perceptions of school control. The first objective is to systematically analyze the spatial structure of the selected schools, while the second is to assess how the built environment could influence teachers’ sense of control.

4.2.1 Schools’ spatial context analysis. To investigate the spatial context of the schools, this study integrates:

- (1) Axial Map Analysis from space syntax theory to assess spatial connectivity, movement potential, and visibility within each school.
- (2) Morphological Metrics, which evaluate the school’s interface with the street (porosity) and its plot coverage ratio, offering insights about school plot relationship with the street network and the articulation of the school unit functions in the plot

Table 1. Schools’ overview

School ID	Year	City	No. Students	No. Teachers	Student – Teacher ratio	School type	No. of floors (including ground floor)	Percentage of interface with the street (School porosity)
S1	2003	C1	347	57	6.09	T1_Courtyard-Based layout	2	40%
S2	2005	C1	265	47	5.94	T2_Finger-Based layout	2	46%
S3	2011	C2	430	55	7.82	T1_Courtyard-Based layout	2	100%
S4	2002	C3	386	60	6.43	T2_Finger-Based layout	2	56%
S5	2003	C4	414	63	6.57	T2_Finger-Based layout	1	46%

Source(s): Authors’ own work



Figure 3. Images of school buildings within their immediate urban context. Source: Authors' own work

Axial map analysis is a foundational method in space syntax that represents a spatial system through the fewest and longest lines of sight and movement required to cover all accessible areas. These axial lines denote potential movement pathways and visibility corridors within a built environment. In the case of school buildings, an axial line typically extends along a corridor and intersects at access points such as classroom doorways and common areas. However, as [Sailer \(2010\)](#) points out, conventional axial mapping presents limitations at the building scale, as it does not fully account for localized spatial experiences.

To address these challenges, this study employs a modified axial mapping approach that incorporates convex spatial segmentation, where individual spaces are defined based on both geometric configuration and functional roles. For example, in a classroom, the area near the entrance and the space in front of the whiteboard are considered distinct convex units,

reflecting their different spatial functions (see Figure 4). All axial maps have been generated by the authors based on existing scholarly work in related studies in the field of space syntax (Sailer, 2018).

Therefore, by constructing and analyzing an axial map, different areas' spatial metrics can be evaluated, identifying how easily and frequently people are likely to move through and interact within space. As Hillier (2003) notes, spatial arrangements are fundamentally about seeing and moving, with syntactic analysis confirming that spatial design facilitates both physical mobility and cognitive understanding. This argument underscores the value of axial maps in capturing both the spatial structure and cognitive aspects of space.

This study employs axial map analysis and the choice metric to explore a perceptual question: How does the configuration of a school's layout influence teachers' perceptions of control within the school environment? The control metric assesses how much a specific unit space regulates access to its surrounding neighbors, considering the number of alternative connections available to each adjacent unit space (Al-Sayed *et al.*, 2014). This method comprehensively explains the interplay between physical space and human perception by linking spatial characteristics with perceptual outcomes.

Figure 5 shows the areas in the schools of the sample that offer more route alternatives and, therefore, the areas of the school that have more connections. Apparently, in all sampled schools, central circulation corridors are consistently characterized by higher axial control.

In addition to space syntax analysis, morphological metrics are employed to assess the physical characteristics of each school's spatial layout. Two key measures are considered:

- (1) School Porosity, which quantifies the degree of interaction between the school and its surrounding street network. This is measured as the percentage of the school perimeter that interfaces with public streets, providing insight into how external accessibility and exposure may influence teachers' sense of control.
- (2) Plot coverage ratio, which assesses how compact or dispersed the school's built form is within its plot. This is calculated as the ratio of the building footprint (m^2) to the total school plot area (m^2), offering a spatial measure of functional concentration on the ground floor.

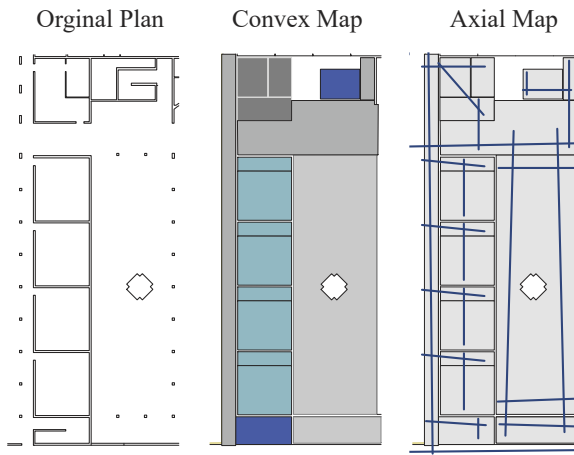


Figure 4. Generation of axial line map based on the original plan and convex map. Source: Authors' own work

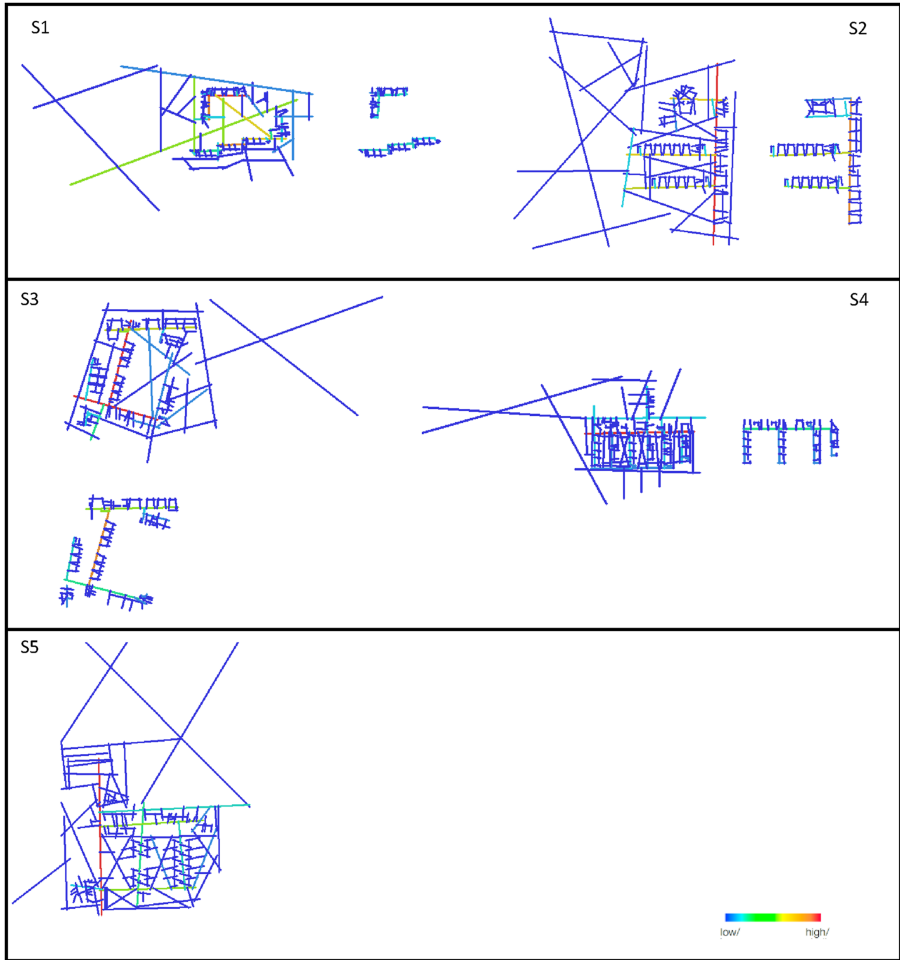


Figure 5. Axial map analysis highlighting in red colors the routes with higher axial choice in the five schools of the sample. Source: Authors’ own work

4.2.2 Teachers’ perceived sense of control: teachers’ survey study. Teachers’ perceived sense of control was assessed through a standardized online questionnaire, administered after ethical approval from the Centre of Educational Research and Evaluation of Cyprus. Following a pilot study (Yin, 2014), revisions were made to address issues, and only responses from the final version were used. The survey was sent to all 282 teachers, with voluntary participation. Seventy-three completed responses were received (25% response rate), ranging from 11 to 20 per school (Table 2).

Table 2. Number of teachers’ responses per school

School ID	S1	S2	S3	S4	S5
No of teachers’ responses	13	20	13	16	11

Source(s): Authors’ own work

Data collection occurred between October and November 2020, during a period when Cypriot schools operated under COVID-19 regulations. As these restrictions were consistently applied across all school sites, the comparative reliability of the responses is not compromised by variation in school governance. In this context, the study treats COVID-19 as a shared external factor across all schools, thereby maintaining the internal validity of the sample.

The questionnaire was structured into four sections: (1) General participant information, (2) Frequency of activities, (3) School community, safety and control, and (4) Socio-educational dynamics introduced by COVID-19 regulations. Respondents rated their experiences using a 5-point Likert scale, ranging from “strongly disagree” (1) to “strongly agree” (5).

To facilitate statistical analysis, standard outlier diagnostics and standardized residuals were first tested. No influential cases were identified that would warrant exclusion. Secondly, an exploratory factor analysis (EFA) with varimax rotation was conducted to reduce multivariate data complexity. Factor analysis is a variable reduction procedure in which a series of variables are replaced by a few factors that summarize the relationships between the variables. This approach was deemed necessary, as the relationship of school building to school practices is a relatively complex phenomenon and thus cannot be measured via single questions.

It has also verified that all assumptions were met (i.e. normal distribution, all scale variables, etc.). Then, the factor analysis was implemented. Initially, the KMO value was 0.64. Hence, some variables with low KMO have been removed from the model to ensure a KMO above 0.80. Ultimately, principal component analysis suggested grouping the variables into three factors:

- (1) Issues with School Control
- (2) Strong School Community
- (3) School’s Adaptation to Change (e.g. COVID-19 regulations)

Lastly, a reliability test was conducted to assess the internal consistency of the model (Cronbach’s alpha was above 0.70 for all variables). For the purposes of this study, only the “Issues with School Control” factor was analyzed. This factor was derived by grouping responses to the following statements:

- (1) “We have issues with students’ delinquent behaviors.”
- (2) “We have had to add rules to comply with COVID-19 restrictions.”
- (3) “We make significant efforts to ensure students follow the rules.”
- (4) “I experience increased work-related stress due to additional regulations.”
- (5) “It is difficult to control students.”
- (6) “Despite the rules implemented, students find ways to circumvent them (e.g. meeting with friends despite COVID-19 restrictions).”

4.2.3 Statistical analysis. A series of statistical analyses were conducted to test the proposed hypotheses (see [section 3](#)). Firstly, a Kruskal–Wallis test examined whether teachers’ perceptions of school control differed significantly between schools. This non-parametric method was chosen due to the small sample size per school and non-normal data distribution. Secondly, a multiple linear regression analysis was performed by considering all teachers’ responses and all spatial and morphological variables in a unified framework. “*Issues with School Control*” was used as the dependent variable to explore the relationship between schools’ spatial configuration and teachers’ perceived sense of control. The independent variables included “*school axial control*”, “*plot coverage ratio*”, and “*schools’ porosity*”. Each

teacher's response was matched to the spatial values of their school, and models were developed according to the study's predefined hypotheses.

All analyses were conducted using RStudio and [DepthmapX \(2022\)](#), using packages including `rgeos`, `rgdal`, `maptools` ([Bivand et al., 2019](#)), `dxfspace` ([Koutsolampros, 2020](#)), `Velma`, and `sp`. Data visualization and plotting were carried out using base R and `png` functions.

By integrating quantitative spatial analysis with perceptual survey data, this methodology provides a comprehensive framework for evaluating the relationship between school layout and teachers' perceived sense of control, contributing to evidence-based school design strategies that enhance school management.

5. Results

Results aim to address the research hypotheses and are discussed in two sections (see [Section 4](#)). Firstly, differences between schools of the sample are discussed through a Kruskal–Wallis test. Secondly, multiple linear regression models examine the relationship between teachers' perceptions of control and spatial – morphological variables.

5.1 Differences between schools of the sample

A Kruskal–Wallis test was conducted to determine if there were differences in teacher's perceived sense of control in the different schools of the sample. Distributions of teacher's perceptions about issues with school control were not uniform for all groups, as assessed by visual inspection of a boxplot ([Figure 6](#)), while the Kruskal–Wallis test showed a statistically significant difference between the different Schools, $\chi^2 = 34.26$, $p < 0.001$.

To validate this finding, a permutation test with 10,000 iterations was performed, confirming the significance of the Kruskal–Wallis results ($p = 0$), indicating that the observed differences were highly unlikely to have occurred by chance.

Secondly, a post-hoc Dunn's test with Benjamini–Hochberg adjustment was conducted to identify which schools differed. The results revealed that School 3 and School 4 differed significantly from the other schools. In particular, significant differences were found between:

- (1) School 1 and School 3 ($Z = -3.68$, $p = 0.000791$)
- (2) School 5 and School 3 ($Z = -5.51$, $p = 0.000000349$)
- (3) School 2 and School 3 ($Z = -4.14$, $p = 0.000177$)
- (4) School 5 and School 4 ($Z = -3.33$, $p = 0.002183$)

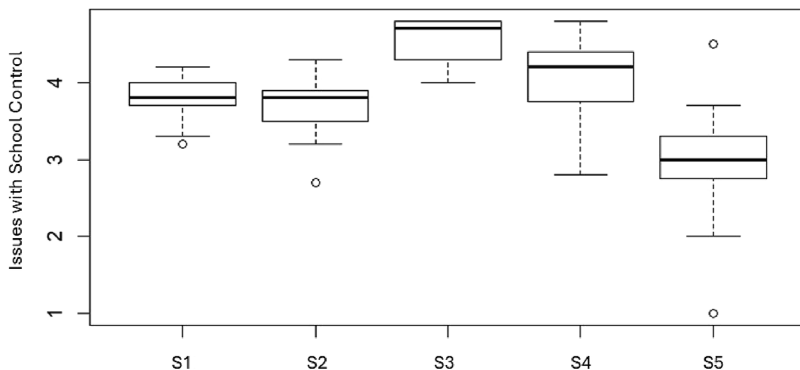


Figure 6. Kruskal–Wallis test investigating the differences between schools. Note: The higher the mean value the more issues the school faces with school control according to the teachers. Source: Authors' own work

(5) School 3 and School 4 ($Z = 2.56, p = 0.0210$)

In more details, teachers in School 3 appear to face more issues with school control compared to teachers in other schools in the sample. In contrast, School 5 recorded the lowest mean score, indicating that, according to teachers' perceptions, this school has the fewest issues related to student supervision, distribution and management.

Table 3 provides an overview of the spatial properties examined in this study, based on the proposed hypotheses. The table shows, for instance, that Schools 1 and 3 differ significantly not only in terms of teachers' responses but also in their spatial characteristics. School 1 has higher axial control, and significantly lower plot coverage ratio and school porosity. This suggests that School 1 offers greater axial control, thus, more movement choices and better-connected circulation routes, while also having significantly less exposure to the surrounding street network compared to School 3.

The above results could, therefore, suggest that differences in school layout may contribute, to some extent, to teachers' perceived sense of control. However, to address such a complex question, multiple linear regression models were employed.

5.2 Modeling teachers' perceptions

Following this study's hypotheses, five regression models (Table 4) have been employed to analyze spatial factors that might affect the degree to which teachers perceive that their school faces issues with control. The dependent variable, derived through factor analysis, includes statements regarding student delinquency, adherence to COVID-19 protocols and general ease of managing students and is named "Issues with school control".

All models developed satisfy the basic requirements for multiple regression analysis, since normality and homoscedasticity are satisfied for all significant models. Also, there is no pattern in the scatter of the fitted values and residuals and the width of the scatter as predicted values increase is roughly the same. The scatter plots of fitted values vs residuals show no discernible pattern. The variance inflation factor (VIF) scores are close to 1, indicating no multicollinearity issues. Therefore, the application of multiple linear regression is justified.

Following with hypotheses of this study, the first model considers Axial Control as the independent variable, explaining 42% of the variation in perceived control issues in schools (Adjusted $R^2 = 0.42$). The coefficient for Axial Control is -2808.3 ($SE = 392.9, \beta = -0.65$), indicating a significant negative relationship, suggesting that higher axial control is associated with fewer perceived control issues.

The second model examines the impact of School Porosity on the dependent variable. This model explains 41% of the variation (Adjusted $R^2 = 0.41$). The coefficient for School Porosity is 0.78 ($SE = 0.11, \beta = 0.66$), indicating a significant positive relationship, where higher porosity correlates with more perceived control issues.

The third model tested whether Axial Control and School Porosity could jointly predict teachers' perceptions of school control. However, the model returned insignificant results, suggesting that while both spatial factors may be relevant when considered individually, they do not significantly contribute to explaining the dependent variable when combined in the

Table 3. Key spatial variables used by this study that highlight potential spatial differences among the sampled schools (only mean values per school are presented)

	S1	S2	S3	S4	S5
Axial control	1.00	0.99	0.98	0.99	1.00
Plot coverage ratio	0.06	0.12	0.11	0.09	0.10
School porosity	40%	45%	100%	56%	46%

Source(s): Authors' own work

Table 4. Regression models

		B(SE)	β	VIF
<i>Model 1: Axial control</i>				
Independent variables	Constant	2846.4 (389.9)**		
	Axial Control	-2808.3 (392.9)***	-0.65	N/A, one variable
Adjusted R^2		0.42		
<i>Model 2: School porosity</i>				
Independent variables	Constant	16.70 (6.61)*		
	School Porosity	0.78 (0.11)***	-0.66	N/A, one variable
Adjusted R^2		0.41		
<i>Model 3: Axial Control and school porosity</i> Significant but unreliable results				
<i>Model 4: Axial Control and density of the school on the ground</i>				
Independent variables	Constant	4237.6 (429.8)***		
	Axial control	-4148.5 (426.0)***	-0.95	1.53
	Density of the school on the ground floor	-610.8 (118.7)	-0.50	1.53
	Adjusted R^2	0.58		
<i>Model 5: School Porosity and density of the school on the ground</i> Insignificant results				
Note(s): * $p < 0.05$, ** $p < 0.01$, *** $p = 0.001$, $n = 73$				
Source(s): Authors' own work				

same model. This implies that these spatial conditions may interact in more complex ways and do not operate additively in shaping teachers' perceptions of school control.

The fourth model introduces the Plot Coverage Ratio alongside Axial Control. This model explains 58% of the variation in perceived control issues (Adjusted $R^2 = 0.58$), the highest among all models. The coefficients for Axial Control and Plot Coverage Ratio are -4148.5 (SE = 426.0, $\beta = -0.95$, VIF = 1.53) and -610.8 (SE = 118.7, $\beta = -0.50$, VIF = 1.53), respectively. These results indicate significant negative effects on perceived control issues from both variables.

Lastly, Model 5, which included School Porosity and Plot Coverage Ratio, returned insignificant results, suggesting that these variables do not significantly explain variation in the dependent variable when combined.

Overall, these models indicate that Axial Control and School Porosity significantly affect teachers' perceptions of control. Higher Axial Control and Plot Coverage Ratio are linked to fewer perceived issues, while greater Porosity correlates with more. Model 4 is the strongest, explaining 58% of the variance and incorporating the most relevant predictors of perceived control.

6. Discussion

The discussion is organized into three parts. First, we synthesize the findings, compare them with the earlier hypotheses, and relate them to existing literature. Second, we consider their implications for school design and educational policy. Finally, we outline the study's limitations and suggest directions for future research.

6.1 Key findings

The findings of this study provide substantial insight into how school design influences teachers' perceived sense of control, particularly in lower secondary schools in Cyprus. Table 5 summarizes the results and compares them with the hypotheses introduced earlier, indicating whether each hypothesis was supported. Hypotheses 1, 2 and 4 were supported by this study, highlighting key spatial conditions that appear to be important when considering teachers' perceived sense of control.

Axial control, ease of movement and perceived sense of control. The correlation between higher axial control and reduced control issues aligns with Space Syntax theory and existing literature (Hillier, 1996; Sailer, 2015). The results suggest that schools with high axial control provide clear, direct pathways that facilitate movement and visibility, enabling teachers to feel that they can supervise the school more efficiently. This finding underscores the role of visually well-connected layouts in enhancing the manageability of school environments, where teachers can remain accessible, responsive and better attuned to student needs.

School porosity and exposure to external networks. The study shows a clear relationship between school porosity and increased control challenges. This finding is consistent with earlier studies that emphasize the need for controlled access points in school design to ensure safety and supervision (Greenman, 1988; Moore *et al.*, 1979). This suggests that while openness and permeability can foster engagement with the surrounding environment, they must be carefully balanced against the need for restricted access points to maintain a secure and well-regulated educational space. For urban schools, especially in high-density areas, unregulated access and high street exposure increase vulnerability to disturbances, undermining internal spatial organization. Thus, strategic design interventions, such as well-connected layouts, can help preserve functional permeability while limiting unnecessary disruptions.

Plot coverage ratio and school supervision efficiency. Another significant finding is the role of plot coverage ratio in the perceived experience of fewer control issues, particularly when combined with high axial control. Compact and functionally integrated layouts provide enhanced visibility and ease of movement, enabling teachers to respond more effectively to student activity and potentially fostering a stronger school community (Sailer, 2018).

Table 5. Summary of supported and rejected hypotheses

A/ A	Hypothesis	Regression model	Result
H1	Schools characterized by higher axial control will lead teachers to perceive fewer issues with school control, as teachers can supervise these school more easily	Model 1	Proven
H2	Teachers in schools with lower porosity (i.e. less exposure to the street network) are more likely to perceive fewer issues with school control	Model 2	Proven
H3	Teachers in schools with higher axial control and lower porosity are more likely to perceive fewer issues with school control	Model 3	Not proven
H4	Schools characterized by higher axial control and higher plot coverage ratio will lead teachers to perceive fewer issues with school control, as teachers can supervise these schools more easily	Model 4	Proven
H5	Schools characterized by lower porosity and higher plot coverage ratio will lead teachers to perceive fewer issues with school control, as teachers can supervise these schools more easily	Model 5	Not proven

Source(s): Authors' own work

6.2 Contribution and implications

This study contributes to knowledge in a variety of ways. Firstly, it is the first to quantitatively assess the relationship between teachers' perceived sense of school control and the socio-spatial characteristics of school layouts. By integrating spatial data with user perceptions in a unified database, it provides an evidence-based framework for understanding how architectural design influences users' perceptions. A key strength of this research lies in its ability to integrate spatial and user-perception data into a unified analytical model, allowing a behavioral research question to be addressed through a spatial-analytic lens. As such, the study underscores the importance of analyzing school environments holistically, considering both spatial organization and its impact on users' lived experiences.

Methodologically, the study employed a systematic and replicable workflow, combining multiple data streams using coded procedures in R. This approach enhances transparency and supports the growing emphasis on reproducibility within architectural and spatial analysis research. Its rigor strengthens the reliability of the findings and allows a more nuanced understanding of how specific spatial configurations are associated with teachers' perceptions of control. The study also advances the application of Space Syntax theory in educational contexts, extending its relevance to school design and planning.

Conceptually, the present study not only builds on prior research exploring school environment and daily school life but also contributes to growing evidence linking school layout to perceived and actual safety in secondary education settings. Recent research by [Liu et al. \(2025\)](#) emphasizes that natural visibility and spatial openness within and around school premises significantly influence school safety outcomes. Their analysis of crime patterns in Philadelphia demonstrates that configurations enabling passive surveillance correlate with lower violent crime rates. These findings support the current study's argument that spatial properties such as axial control can enhance teachers' ability to supervise behavior and reduce undesired activities.

In practice, the findings offer architects and policymakers evidence-based recommendations for optimizing school layouts. Designers may be encouraged by the idea that their decisions can influence teachers' perceived control. By creating local gateways or chokepoints to less-connected areas, architects can improve supervision capacity and, consequently, the sense of control. School designs should incorporate spaces with higher axial control, such as key corridors or transitional areas acting as local access points, to support natural monitoring, structured movement and spatial order. Architects should be also aware that highly dispersed or fragmented school layouts may result in lower axial control, reducing spatial legibility and the ease with which staff can oversee and manage movement. Designers might consider incorporating strategically placed connectors, such as transitional spaces or junctions that control access to adjacent zones.

These findings also suggest that architects should pay closer attention to the design of corridors in schools. As recent studies highlight, well-connected corridors are not merely circulation routes but can support interaction and co-presence ([Sailer, 2018](#); [Fouad, 2021](#)). At a global scale, they link separate areas; locally, they control access within immediate contexts. Beyond circulation, they contribute to legibility and social life, crucial for both students and teachers.

Additionally, when designing schools on plots with high porosity, which might suggest many uncontrolled access points to the surrounding street network, architects should carefully balance openness with security. While engagement with the surrounding environment is valuable, unregulated permeability can introduce control challenges and rules reinforcement and thus affect the school community's character.

A school design to avoid is School 3, which was reported by teachers as having the most control-related issues among the sampled schools. Notably, its design is characterized by a less coherent spatial composition, the lowest axial control, and the highest plot coverage ratio in the sample. From a design perspective, School 3 is the only school in the study with an

outward-facing courtyard, and its overall layout appears to be shaped more by plot constraints than by intentional spatial planning.

From a policy perspective, by considering the influence of school's porosity on teachers' sense of control, it could be argued that policymakers, when selecting potential plots for school developments, should carefully consider the constitution of the school perimeter by street network. Ideally, they could define preferred plot characteristics to support safer environments and reduce delinquent behavior. Additionally, it could be valuable for policymakers to re-examine the design guidelines to define the ideal plot coverage ratio. This could have significant implications for the actual use of space since schools that establish coherent spatial relationships between classrooms, administrative offices and communal spaces can foster natural spatial control.

These findings can be enriched by literature on teacher agency and critical education studies. Teachers' perceived sense of control over school spaces, as discussed in this study, not only could reflect spatial affordances but could also intersect with broader dynamics of professional autonomy, efficacy, accountability and relational trust (Priestley *et al.*, 2015). In particular, in contexts like Cyprus, where school architecture remains primarily standardized, our findings could highlight how spatial design can either constrain or support teachers' ability to navigate their roles as facilitators and caretakers, especially when more than 30% of their learning time is devoted to disruptive students' behaviors (OECD, 2009). In this light, this study's results could also suggest that well-connected schools, when thoughtfully designed, can offer a balance between supervision and autonomy and simultaneously can support both teacher agency and student wellbeing. This is relevant even for open, multifunctional spaces designed for collaboration and innovation in student-centered learning.

However, given the economic constraints affecting public construction, full implementation of ideal design models may not always be feasible. Nonetheless, strategic interventions can still improve spatial legibility and school life. As noted by Psathiti and Sailer (2023) and Fouad (2021), school layout, leadership rules and school life interact continuously and should be considered together. Examining these dimensions allows school leadership to implement targeted micro-interventions – such as addressing problematic circulation zones, redefining outdoor access or repurposing transitional spaces – to better align spatial use with pedagogical and social needs. Such initiatives foster adaptable learning environments and support EU (2024) goals for inclusive, healthy and sustainable infrastructure under the revised Energy Performance of Buildings Directive, promoting a holistic approach that integrates spatial quality with well-being, participation and equity.

6.3 Limitations and further research

While this study provides valuable insights into the relationship between spatial configuration and teachers' perceptions of control, several limitations should be noted. The small sample (five schools) limits generalizability, and the focus on lower secondary schools in Cyprus may reduce applicability to other contexts. The 25% survey response rate also means non-respondents' views are absent; however, such rates are generally acceptable in educational perception studies and offer a sufficient basis for exploratory analysis.

To broaden these findings, future research should include a larger, more diverse sample across educational levels and locations to improve generalizability. Longitudinal studies could assess how design changes affect teachers' perceptions and student behavior over time, offering insight into the long-term impact of spatial interventions. Applying the model to primary, secondary and vocational schools would test its validity in varied settings. Beyond porosity, future work could also explore how a school's integration with its surrounding neighborhood and street network influences teachers' perceived control.

In addition to expanding the sample, future research should incorporate extensive built-environment data from multiple regions, exploring how socio-spatial factors interact with broader educational and cultural contexts. Investigating cross-cultural variations in school

governance and spatial organization would provide a richer understanding of how different educational systems balance openness with institutional control.

By addressing these gaps, future research can refine our understanding of the relationship between spatial configuration and school governance, offering robust insights for educational architects, policymakers and institutional planners. Ultimately, optimizing school environments through spatially informed design strategies has the potential to enhance learning experiences, improve supervision and foster structured, supportive educational settings – benefiting both teachers and students alike.

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Further reading

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