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Examining the Impact of Flexible Partitions in Educational Spaces on the Sense of Belonging of High School Female Students: A Partial Least Squares Approach

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ABSTRACT

It is well recognized that just as humans influence their environment, the environment also shapes human behavior. Educational spaces, in particular, occupy a significant part of individuals' lives during the formative stages of personality development. Therefore, careful design and construction of these spaces play a vital role in addressing students' physical and psychological needs. Among these needs, the sense of belonging to a place is especially important and is strongly linked to spatial design. Rigid and conventional school environments cannot fully address students' diverse requirements; instead, flexible design strategies are essential. Flexibility in spatial design fosters a sense of belonging by enabling both personal and group-based spatial arrangements. This study investigates the effect of flexible and transformable partitions in educational spaces on students' sense of belonging and proposes practical design strategies. A mixed descriptive–analytical approach was adopted, beginning with a literature review and theoretical analysis, followed by case study evaluations. Subsequently, a structured questionnaire was administered to the target population, and the data were analyzed using structural equation modeling with a partial least squares (PLS) approach, employing SPSS and SmartPLS3 software. The results confirm that flexible partitions significantly enhance students' sense of belonging through various design interventions, including the integration of large windows, grouping of spaces with deliberate adjacency, flexible forms, movable furniture and panels, purposeful circulation, potential for future expansion, collective and individual rest/study areas, enhanced transparency, the use of terraces or courtyards, and the creation of multi-functional spaces.

1. INTRODUCTION

A significant portion of an indi7vidual's life achievements is influenced by the environment in which they live. Educational spaces, particularly schools, are among the first social environments that individuals encounter;

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therefore, the quality of their design has a profound impact on students' learning and educational outcomes. Naturally, greater attention to the design of educational environments contributes to more effective teaching and learning. Consequently, any development or modification of school curricula should be accompanied by corresponding adjustments in the design of these spaces, considering students' cognitive, physical, and psychological needs. Moreover, schools should provide students with the individual and social skills required for their future lives, preparing them for active participation in society.

Environmental psychologists assert that physical conditions exert an undeniable influence on human behavior and thought; examining human behavior without considering the surrounding physical environment is insufficient [1]. Therefore, one of the key factors affecting school architectural design is understanding students' needs what type of environment they require for learning activities and which environmental variables contribute to their well-being [2].

The sense of belonging is a critical indicator in evaluating human-environment interaction and in creating high-quality, human-centered environments. At this level, an individual develops a deep connection with the environment, experiencing a form of identification or empathy with the space [3]. Providing private spaces within educational environments, as well as areas that foster social interaction while allowing students to maintain their individuality, is essential [4].

Furthermore, it is important to recognize that learning does not occur solely within classrooms; a significant portion of students' experiences and knowledge acquisition takes place in social areas such as schoolyards, open or semi-open spaces, corridors, and other transitional spaces. In many school designs in Iran, this aspect has often been overlooked. The role of education in societal development is undeniable, and educational spaces are a major architectural domain influencing social transformation [5].

Regarding the principles of educational spaces, school architecture is recognized as a core component of learning environments, and flexible design of these spaces can provide dual functionality for teaching and learning. Modern learning environments require dynamic assumptions that extend beyond traditional industrial-era paradigms [6].

Based on these definitions, it is expected that school environments should possess specific capabilities enabling students to interact with and modify their educational spaces whether through rearranging classroom furniture or adjusting partitions so that the environment can be adapted to varying student needs. This concept forms the foundation of flexible schools.

1.1. Research Objectives

1. To evaluate the impact of flexible and transformable partitions in educational spaces on the sense of belonging of female high school students.
2. To propose design strategies for implementing flexible partitions in girls' high schools.

Considering the above, this study aims to examine how flexible environments, which enable interactive participation of students both in terms of physical aspects of educational spaces and learning methods affect students' sense of belonging. Consequently, the psychological comfort gained from such environments is expected to have positive effects on students' motivation and overall well-being.

2. LITERATURE REVIEW

From the trajectory of learning environment design in educational systems, it can be understood that we are dealing with specific planning and design approaches for both present and future learning environments, reflecting the nature and pace of ongoing changes. Several studies have investigated this domain.

One study highlights that, given rapid global changes and the development of architectural tools, educational approaches required by society can be updated through architectural flexibility. Flexibility can influence education in two ways: first, by updating educational approaches using contemporary architecture, and second, by generating innovative architectural designs aligned with new educational approaches. This study assumed a relationship

between flexible design and its impact on educational outcomes, seeking to establish the link between architecture, educational performance, and flexibility [7].

Another study emphasizes that, due to the significant influence of educational space design quality on student learning and teaching methods, attention to flexible design in educational spaces has increased in recent years. By examining several schools designed with flexible approaches and analyzing these cases, researchers investigated the impact of such elements on students' sense of vitality. They concluded that flexible design in schools increases students' interest in school and, consequently, enhances their sense of vitality [8].

A study on the New Zealand educational system indicates that the system is suitable for all students, regardless of ability, and supports the full development of each student's potential. In this context, the design and development of new primary school buildings and the renovation of existing facilities are promoted to enable modern educational practices. These practices prepare students for the applications of the 21st-century global economy. Flexible educational environments encourage teachers and enable them to employ participatory, dispersed, and facilitative instructional approaches, often implemented in team-based, multi-student shared spaces [9].

Research comparing student behavior in traditional classrooms versus flexible learning classrooms shows that changes in constructed learning environments, combined with student-centered instruction, can positively affect adolescent behavior during class. This aligns with environmental psychology research, which long asserts that human behavior and the built environment are closely intertwined. The primary difference between these two learning environments is that in flexible learning spaces, teachers actively relinquish control over the students' location and workflow. This pedagogical shift, combined with environmental features, facilitates student autonomy and interaction with both the space and its users [10].

The Organization for Economic Co-operation and Development (OECD) notes that when students feel part of a school community, they are more likely to achieve better academically and exhibit higher motivation for learning. The study examines differences between countries in students' sense of belonging in school and how this feeling relates to gender, socio-economic status, and students' migration backgrounds. It also investigates how school climate and student-teacher relationships influence students' perceptions of being valued members of the school community [11].

As research demonstrates, changes in student expectations and attitudes, and the relationship between active participation and learning, challenge institutions to reconsider classroom design. Traditional college classrooms with fixed, lecture-style configurations do not align with current understanding of how students learn or how they are expected to learn. Evidence suggests that redesigning classrooms into active learning spaces can enhance student engagement [12].

This study is particularly significant in the Iranian context, where traditional teaching methods dominate and students' sense of interest and belonging in schools is often low. Based on previous studies, it is expected that enabling students to modify their learning environments will enhance their sense of belonging and attachment to the school. The distinction of this study from prior research is its focus on the physical components of classrooms specifically, the impact of flexible partitions on students' sense of belonging.

3. THEORETICAL FOUNDATIONS

3.1. Environment

The nature of society does not occur in a vacuum; its functioning requires a context, which is the environment, and people constantly interact with it. The relationship between humans and the environment is considered a mutual and reciprocal interaction. Environmental psychology studies the effects of the environment on human behavior. According to Hallpach's theory, environmental information can be categorized into three types: natural environment (human-altered), social environment, and cultural environment (population). Another perspective classifies the environment into physical (natural and built), social (group-based), and psychological-behavioral (reaction-based) environments.

Social interactions occur within the natural-built environment context, influencing social behavior, while at the same time, behavior reflects back on the physical environment, establishing an objective relationship between the two [13].

The environment encompasses the relationships between objects, between objects and people, and among people themselves. It possesses order, patterns, and structure. Human life, cultural norms, and communication systems ultimately regulate the environment [14]. Human actions in intervening and shaping the built environment aim to respond to human needs. From this perspective, "need" is defined as a distinctly human motivational and behavioral category. Human needs, rooted in innate nature, govern behavior, and their relative satisfaction ensures human survival. These needs are addressed through various individual and social mechanisms [15].

3.2. Sense of Belonging

The sense of belonging is a central topic in environmental psychology and a key criterion for evaluating high-quality environments, where the environment plays a significant and influential role. Reviewing the literature reveals a wide range of terminology and approaches to describe this unique perception, leading to a diversity of terms and meanings. Commonly used terms include cognitive complexity, commitment, attachment, prioritization, and place identity. Scholars have provided various perspectives on sense of belonging, summarized in Table 1.

Table 1. Scholars' perspectives on sense of belonging (Source: Author, based on theoretical references)

Scholar	Perspective
Altman	Views sense of belonging in the environment as more than a cognitive experience, including cultural beliefs connecting individuals to the environment; identifies three environmental attributes: scale, specificity, and accessibility.
Rapoport	Emphasizes socio-cultural components in shaping the built environment; through the theory of nonverbal communication, he categorizes the environment into fixed, semi-fixed, and movable elements, whereby individuals interpret their meanings based on cultural codes and mental schemas.
Kevin Lynch	Describes belonging in designed spaces through distinctiveness and separation, highlighting it as a core factor in creating sustainable human spaces.
Robert Ryan	Categorizes environmental interactions as active, semi-active, and passive, emphasizing the importance of active engagement in fostering a sense of belonging.

Research indicates that dimensions of place attachment often relate to social environments. Two primary categories emerge:

Social belonging: This type of belonging is primarily based on social interactions and activities within the environment. According to social environment theory, belonging arises from a combination of social elements, where individuals seek connection with aspects of their environment [16].

Physical/place-based belonging: This type derives from ownership and identification with physical elements of a place. Taylor and colleagues, in their study of public spaces in neighborhoods, emphasize physical interaction with objects, corresponding to physical ownership of the place [3].

Key factors contributing to sense of belonging in design include:

Perceptual-cognitive factors: Sense of belonging emerges from personal perception of meanings, symbols, and environmental qualities, consciously or unconsciously processed. Stronger differentiation enhances the likelihood of attachment.

Social factors: Humans have social needs and seek attachment to family and friends. In this social-emotional framework, the environment provides a context for cultural and social activities, where individuals interpret physical elements based on cognitive frameworks, collectively shaping the environment.

Environmental-physical factors: Built elements create spatial differentiation and connections between interior and exterior spaces, fostering attachment. Form, size, color, texture, and scale influence sense of belonging, as does the arrangement of spatial components [17].

Scanlon and Gifford proposed a comprehensive "person-process-place" classification of belonging, a three-dimensional framework where the personal dimension includes both individual and group levels, and the process dimension includes emotions and thoughts [18]. Various theorists have identified factors influencing place attachment, some of which are summarized in Table 2.

Table 2. Scholars' perspectives on factors influencing sense of place attachment

Scholar	Key Factors
Altman	Cultural beliefs, scale, specificity, accessibility
Altman & Low	Scale, legibility, social relationships, temporal aspects, actor-related factors, influencing factors
Rapoport	Cultural and social-symbolic elements of the built environment
Kevin Lynch	Legibility, collective memories, built elements (paths, edges, landmarks, nodes), vitality, identity, meaning, accessibility, control and supervision, proportions
Fritz Steele	Place size, degree of enclosure, contrast, scale, proportions, human scale, distance, texture, color, smell, sound, visual variety, identity, history, imagination and illusion, mystery, pleasure, security, vitality, excitement, memory
Salvesen	Landscape location, spatial integration, physical character, ownership, authenticity, amenities, natural elements (e.g., water, plants, sky, sun), private and communal spaces

(Source: Author, based on theoretical foundations of the study)

According to research, physical/place-based attachment derives from elements and components of the built environment as part of the human cognition and identity process. These elements can be categorized as natural or built (artificial) components. Based on scholars' theories, spatial-physical factors influencing sense of belonging can be grouped into three categories: functional, experiential-aesthetic, and environmental (Table 3).

Table 3. Scholars' perspectives on spatial-physical factors affecting sense of belonging

Functional	Experiential-Aesthetic	Environmental
Permeability	Nature	Sensory richness
Safety	Geographic/environmental potentials	Meaning
Diversity	-	Legibility
Flexibility	-	-

(Source: Author, based on theoretical foundations of the study)

3.3. Sense of Belonging in Educational Environments

Humans, and adolescents in particular, have a natural tendency to form strong social connections and value acceptance, care, and support from others. In the school context, a sense of belonging provides students with feelings of security, identity, and connection, which in turn promote their academic, psychological, and social development.

Adolescents who perceive themselves as part of a school community are more likely to demonstrate better academic performance and higher motivation at school. Students with strong and positive social bonds within the school are less likely to drop out, engage in substance abuse, or skip classes. Furthermore, research has shown that the absence of a sense of connection at school can precede the onset of depression among adolescents. A sense of belonging in school affects both students' academic outcomes and their overall life satisfaction. By the age of 15, many students strongly perceive instances of unfair behavior by their teachers, which can negatively influence their sense of belonging and participation at school. Schools can address this by regularly collecting student feedback

regarding the quality of the learning environment and the social relationships they maintain within the school community [11].

Based on the above, the factors influencing sense of belonging in educational environments can be broadly categorized, as illustrated in Figure 1.

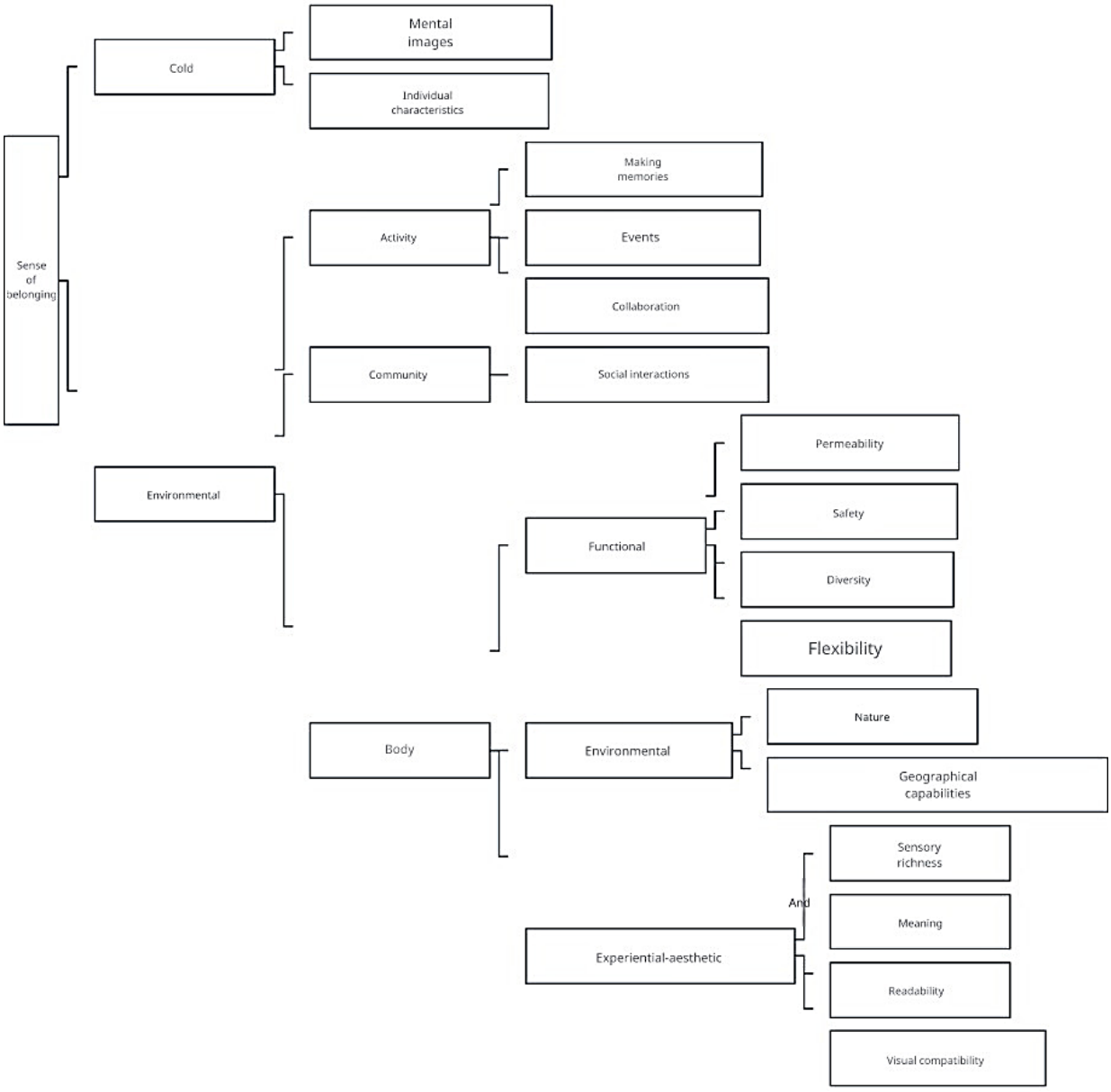

Fig. 1. the factors influencing sense of belonging in educational environments

3.4. Flexibility

Flexibility, linguistically, refers to the ability to adapt to any situation or environment [19]. Simply put, it is the capacity to change in order to suit the environment and respond to its variations in different contexts [20]. Contemporary resilience theories view flexibility as a multidimensional construct, including skills such as problem-

solving. Psychologists argue that resilient individuals are more developed, as their lives are rich in experience and they respond more effectively to mandatory changes [21].

In architecture and design, and specifically in educational spaces which are the focus of this research flexibility refers to spatial adaptability and the organization of the built environment, allowing modifications to meet new conditions, needs, and data [22]. At different scales, various types of flexibility can be defined in educational spaces, including diversity (multi-functional spaces), adaptability (modifications according to different activities or climates), and modifiability (division and aggregation of spaces).

Adaptability (seasonal and daily adjustments): Adaptability is the ability to adjust by transforming into a space with new conditions [22]. For example, in furniture arrangements, a modular seating design is more suitable when two small workshops need to be combined into a larger collaborative space for teachers [23].

Modifiability (division and aggregation): Modifiability refers to increasing or decreasing the quantity and quality of spaces, merging them, and the ability to return to the original plan after expansion or reduction. This capacity allows spaces to respond to growth at different educational levels [24].

Diversity (multi-functional spaces): Diversity refers to the capacity to provide different and effective uses of a space. This type of flexibility relates to both time and location. A flexible model can meet all students' needs with minimal space by adapting, modifying, and diversifying functions [22].

3.5. Flexible Partitions

Traditionally, classrooms are designed with a fixed layout that supports static, one-way teaching [25]. Currently, designers are encouraged by the Ministry of Education to create forward-looking learning environments with more dynamic characteristics [26]. In flexible learning environments, traditional arrangements are replaced with adaptable rooms where furniture is no longer fixed [27]. Altering classroom structure allows teachers to collaborate more effectively by moving beyond conventional layouts.

Wood (2018) argues that the concept of flexibility in a space represents a coherent relationship among space, users, and resources, and that individuals are often overlooked in the equation that defines what makes a space flexible [28]. Teaching in flexible learning environments, where classroom barriers are removed, enables teachers to adopt more effective instructional practices visibly and collectively. Moreover, teachers can learn from each other and share resources collaboratively [29].

Based on the above, key considerations in designing flexible educational environments include:

- Creating appropriate infrastructure for diverse educational activities, so that spaces can accommodate changes in teaching patterns, furniture, and educational equipment.
- Involving students in designing their own learning environment.
- Considering the cultural background and mindset of teachers and students during design.

Furthermore, the arrangement of elements, the balance between solid and void, strongly influences a school's capacity for internal and external flexibility [30]. According to existing studies, Figure 2 presents strategies to enhance flexibility in a learning environment.

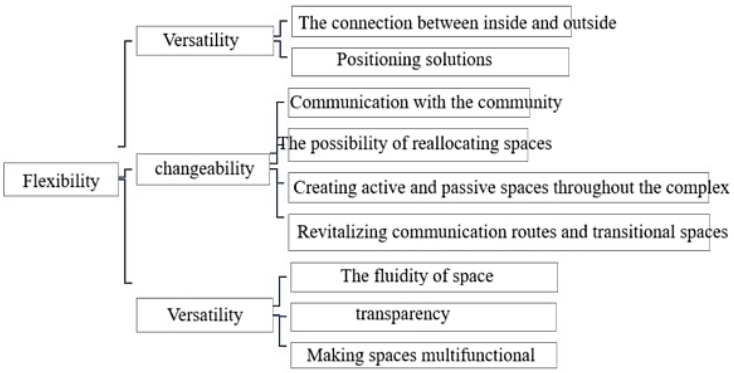

Fig. 2. Strategies for Enhancing Flexibility
(Source: Author, based on theoretical foundations of the study)

(You may include a schematic or table showing flexibility strategies such as adaptable furniture, movable partitions, modular learning zones, multi-functional spaces, etc., as illustrated in your original Figure 2.)

4. RESEARCH METHOD

This study employed a mixed descriptive-analytical approach. Initially, a library-based review and study of related sources were conducted. Then, using the theoretical foundations of the research and case study analyses, a questionnaire was designed and structured. Finally, the written questionnaire was distributed among the target population to examine the initial hypotheses of the study.

Schools with similar dimensions and conditions from different areas of the city were selected. Public schools were chosen due to their comparable number of classrooms, student capacity, educational facilities, and open and closed spaces.

Data Collection Tool: A researcher-developed questionnaire was used, completed by students. It included 43 items using a 5-point Likert scale and was divided into two sections:

Section A: Measured variables affecting students' sense of belonging, including physical and environmental factors. Items were derived from theoretical foundations. The sense of belonging components were divided into individual and environmental subcategories, extending to the specific factor of flexibility.

For descriptive analysis, data entry and statistical tests were conducted using SPSS. For inferential analysis and model evaluation, Partial Least Squares Structural Equation Modeling (PLS-SEM) was performed using SmartPLS3. Model evaluation used factor loadings, reliability, convergent and discriminant validity, and determination coefficients (R^2). Model quality was assessed with shared variance, predictive relevance, and goodness-of-fit indices, while factor loadings were used to rank components.

4.1.1. Partial Least Squares Structural Equation Modeling (PLS-SEM)

PLS-SEM is a non-parametric method used to validate models by simultaneously examining latent and observed variables. It serves as a suitable alternative to traditional covariance-based SEM, especially when:

- The sample size is small, or
- Data are non-normally distributed.

However, PLS-SEM can also be applied to large samples or normally distributed data. Latent variables represent underlying constructs, either independent or dependent, while observed variables correspond to survey items or questions. PLS-SEM allows analysis without assuming specific distributions or measurement scales (nominal, ordinal, interval, ratio). A key assumption is the "predictive relevance," which specifies that the systematic portion of the linear regression should be defined based on expectations of the dependent variable [31].

5. FINDINGS

To evaluate the research model, factor loadings, reliability (internal consistency and composite reliability), convergent and discriminant validity (AVE and HTMT), and determination coefficients (R^2) were analyzed. Model quality was assessed using shared variance, predictive relevance, and goodness-of-fit indices, and factor loadings were used for ranking components.

Reliability Analysis: Internal consistency was measured using Cronbach's alpha, composite reliability (CR), and Dillon–Goldstein ρ. All constructs and indicators affecting students' sense of belonging achieved acceptable reliability above 0.70. Specifically, the flexible partition construct and its components also had reliability above 0.70, indicating acceptable internal consistency.

Convergent Validity: The Fornell–Larcker criterion requires that the Average Variance Extracted (AVE) for each construct exceeds 0.50, meaning that a latent variable explains more than half of the variance in its indicators. The AVE values for all constructs were above 0.50, confirming adequate convergent validity for the proposed model (Tables 4 and 5).

Table 4. Demographic and Construct Variables of Female High School Students in Amol County

Construct / Indicator	AVE	CR	ρA	Cronbach's α	R^2	Adj. R^2	CV-red	CV-com
Sense of Belonging	0.502	0.845	0.857	0.813	0.158	0.155	0.221	0.103
Individual	0.500	0.846	0.749	0.742	0.571	0.570	0.149	0.129
Mental Perceptions	0.609	0.861	0.793	0.783	0.900	0.900	0.513	0.309
Individual Traits	0.501	0.796	0.766	0.756	0.250	0.248	0.066	0.089
Environmental	0.503	0.826	0.818	0.782	0.890	0.890	0.142	0.109
Activity	0.506	0.806	0.784	0.738	0.228	0.226	0.061	0.129
Social	0.500	0.732	0.870	0.855	0.166	0.164	0.068	0.053
Physical / Built	0.501	0.832	0.815	0.787	0.944	0.944	0.198	0.142
Functional	0.508	0.723	0.725	0.711	0.686	0.685	0.149	0.081
Permeability	0.635	0.776	0.714	0.710	0.146	0.143	0.082	0.037
Safety	0.656	0.790	0.779	0.769	0.357	0.355	0.216	0.096
Diversity	0.500	0.725	0.791	0.741	0.677	0.676	0.303	0.050
Flexibility	0.682	0.811	0.735	0.734	0.394	0.393	0.254	0.121
Environmental-Built	0.507	0.877	0.727	0.716	0.542	0.541	0.236	0.164
Nature	0.724	0.840	0.730	0.721	0.701	0.700	0.480	0.201
Geographical Features	0.691	0.817	0.763	0.754	0.620	0.619	0.405	0.140
Experiential-Aesthetic	0.508	0.836	0.763	0.751	0.697	0.646	0.303	0.266
Meaning	0.776	0.874	0.716	0.712	0.759	0.758	0.556	0.300

Notes: Only variables with at least two items were included. Discriminant validity was assessed using the Fornell–Larcker criterion and HTMT. AVE root values (diagonal) exceeded non-diagonal correlations. HTMT values ranged from 0.692 to 0.755, below the recommended threshold of 0.85, confirming adequate discriminant validity.

Table 5. Indices of Factors Influencing Flexible Partitions

Construct / Indicator	AVE	CR	ρA	Cronbach's α	R^2	Adj. R^2	CV-red	CV-com
Flexible Partitions	0.502	0.871	0.841	0.832	–	–	–	0.276
Adaptability	0.715	0.834	0.703	0.701	0.620	0.619	0.419	0.184
Modifiability (Segmentation)	0.500	0.794	0.774	0.759	0.790	0.789	0.364	0.171
Multi-functionality (Diversity)	0.659	0.853	0.748	0.742	0.735	0.735	0.451	0.319

Notes: AVE = Average Variance Extracted; CR = Composite Reliability; ρA = Dillon–Goldstein rho; CV-red = cross-validated redundancy; CV-com = cross-validated communality.

5.1. Coefficient of Determination (R^2)

The R^2 index indicates the proportion of variance explained by endogenous latent variables. According to Cohen (1992), R^2 values of 0.26, 0.13, and 0.02 are considered strong, moderate, and weak, respectively. In the present study, the R^2 values for most constructs and indicators were at a strong level (Tables 4 and 5).

To assess whether the measurement indicators (survey items) adequately measure their corresponding constructs, the Q^2 test for predictive relevance was conducted using cross-validated redundancy. Based on the results in Tables 4 and 5, all cross-validated redundancy values ranged from moderate to strong, indicating high quality of the measurement model. Similarly, the predictive relevance test showed moderate to strong values, confirming the robustness of the model.

Furthermore, given that both the communality and predictive relevance indices of all constructs exceeded zero, the internal and external validity of the proposed model was confirmed [32].

To evaluate the overall fit of the structural model, the Goodness-of-Fit (GOF) index was calculated as the square root of the product of the average variance extracted (AVE) and the R^2 of the dependent constructs. The GOF value obtained in this study was 0.462, which, according to established criteria, indicates a strong overall fit. Therefore, both the structural and measurement models exhibit adequate quality in explaining the study variables.

In conclusion, based on the estimated indices, the proposed model examining the effect of flexible partitions in educational spaces on female students' sense of belonging demonstrates good fit. Figures 3 and 4 illustrate the standardized path coefficients and t-statistics for the relationships between research variables, respectively.

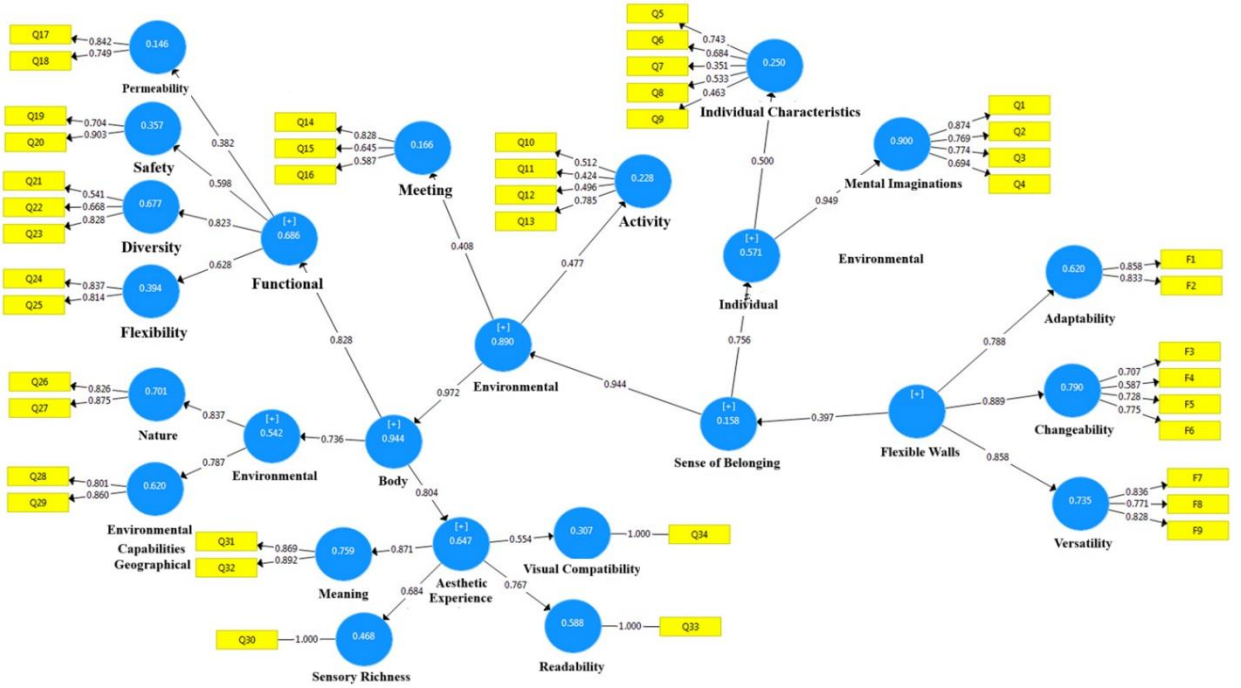

Fig. 3. Structural model of the effect of flexible partitions in educational spaces on female students' sense of belonging ((standardized regression coefficients).

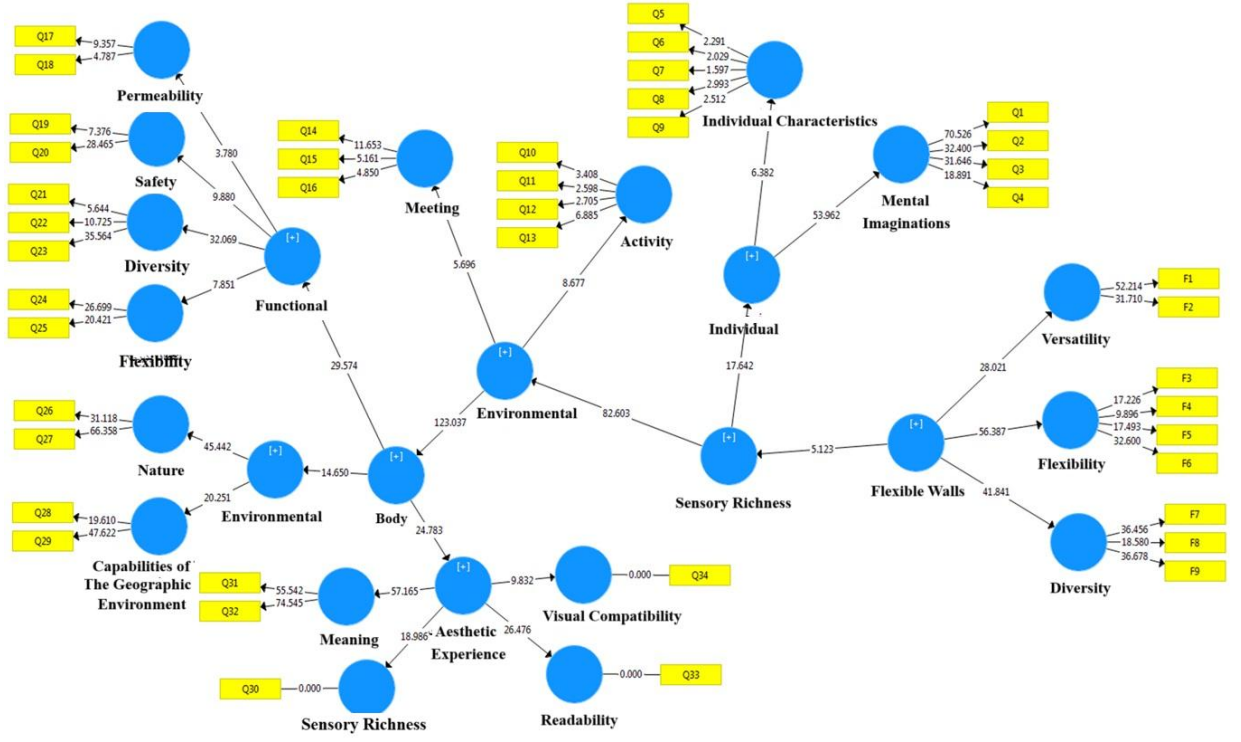

Fig. 4. Structural model of the effect of flexible partitions in educational spaces on female students' sense of belonging (t-statistics).

The figure presents the t-statistics of the paths between flexible partitions and female students' sense of belonging in secondary schools. The results indicate a positive and significant direct effect of flexible partitions on students' sense of belonging ($\beta = 0.397$, $t = 5.123$, $p < 0.001$). Specifically, a one standard deviation increase in the flexibility of partitions corresponds to a 0.397-unit increase in the students' perceived sense of belonging. Table 6 summarizes the direct effect, confidence intervals (95% CI), effect size (f^2), and significance level, confirming the robustness and significance of the hypothesized relationship.

Table 6. Direct effect of flexible partitions on female students' sense of belonging

Direct Effect	β	t	95% CI Lower	95% CI Upper	Effect Size (f^2)	P-value	Result
Flexible partitions → Sense of belonging	0.397	5.123	0.227	0.537	0.187	<0.001	Accepted

Note: CI = Confidence Interval at 95% level.

5.2. Prioritization of Components and Indicators of the Sense of Belonging Variable

The following section examines the impact and prioritization of components and indicators within the sense of belonging variable. To achieve this, the factor loadings of the proposed models were employed. The strength of the relationship between latent variables (factors) and observed variables (indicators) is represented by factor loadings, which range from 0 to 1. Factor loadings below 0.3 are considered weak and are therefore disregarded. Loadings between 0.3 and 0.6 are deemed acceptable, while loadings above 0.6 are considered highly desirable, indicating a strong influence of the latent variable on its indicators.

The factor loadings and associated t-statistics for the subcomponents affecting the indicators of the sense of belonging variable are presented in Table 7.

Table 7. Factor loadings and t-statistics for subcomponents on indicators of sense of belonging

Indicator	Subcomponent	Factor Loading	t-value	Significance	Result	Rank
Individual	Mental perceptions	0.949	53.962	<0.001	Accepted	1
Individual	Personal traits	0.500	6.382	<0.001	Accepted	2
Functional	Accessibility	0.382	3.780	<0.001	Accepted	4
Functional	Safety	0.598	9.880	<0.001	Accepted	3
Functional	Diversity	0.823	32.069	<0.001	Accepted	1
Functional	Flexibility	0.628	7.851	<0.001	Accepted	2
Environmental	Nature	0.837	45.442	<0.001	Accepted	1
Environmental	Geographic capabilities	0.787	20.251	<0.001	Accepted	2
Experiential-aesthetic	Sensory richness	0.684	18.986	<0.001	Accepted	3
Experiential-aesthetic	Meaning	0.871	57.165	<0.001	Accepted	1
Experiential-aesthetic	Legibility	0.767	26.476	<0.001	Accepted	2
Experiential-aesthetic	Visual coherence	0.554	9.832	<0.001	Accepted	4

Table 8. Factor loadings and t-statistics for components on sense of belonging

Indicator	Component	Factor Loading	t-value	Significance	Result	Rank
Physical	Functional	0.828	29.574	<0.001	Accepted	1
Physical	Environmental	0.736	14.650	<0.001	Accepted	3
Physical	Experiential-aesthetic	0.804	24.783	<0.001	Accepted	2
Environmental	Activity	0.477	8.677	<0.001	Accepted	2
Environmental	Social	0.408	5.696	<0.001	Accepted	3
Environmental	Physical	0.972	123.037	<0.001	Accepted	1
Sense of belonging	Individual	0.756	17.642	<0.001	Accepted	2
Sense of belonging	Environmental	0.944	82.603	<0.001	Accepted	1

Table 9. Factor loadings and t-statistics for subcomponents on flexible partitions

Flexible Partitions	Factor Loading	t-value	Significance	Result	Rank
Adaptability	0.788	28.021	<0.001	Accepted	3
Modifiability	0.889	56.387	<0.001	Accepted	1
Versatility	0.858	41.841	<0.001	Accepted	2

6. CONCLUSION

At the outset of the study, two research questions were formulated, which are addressed in the following sections.

Research Question 1: How do flexible walls affect students' sense of belonging?

The sense of belonging construct comprised two main components: individual and environmental. Both components were significant at the 0.05 level, indicating their influence on students' sense of belonging. Examination of the factor loadings revealed that the "environmental" component had the greatest effect, whereas the "individual" component had the least effect on the sense of belonging among female high school students.

The flexible walls construct included three components: adaptability, modifiability, and versatility. According to t-statistics, all three components were significant at the 0.05 level, demonstrating their effect on the flexible walls construct. Further analysis of factor loadings indicated that "modifiability" had the greatest impact, while "adaptability" had the least effect on the flexible walls construct. Based on these results, it can be concluded that flexible walls in educational spaces have a positive and significant effect on the sense of belonging among female high school students.

Research Question 2: How can flexible walls be designed in schools?

Based on the analyses, the flexible walls construct, with its three components adaptability, modifiability, and versatility was significant at the 0.05 level. Examination of factor loadings revealed that "modifiability" (loading = 0.889) had the highest influence, while "adaptability" (loading = 0.788) had the lowest influence on the flexible walls construct. Strategies to achieve these factor loadings are summarized in the tables, and given that modifiability has the greatest influence, it should be prioritized in design, with the remaining components ranked accordingly. Specific design details for each component are as follows:

6.1. Modifiability includes:

1. **Community alignment:** Adjusting the size of collective spaces to match group size and activity type (e.g., classroom groups, friendship groups, small or large groups).
2. **Space reassignment:** Flexible and alternative use of spaces (e.g., using the gymnasium as an assembly hall, or vice versa).
3. **Active and passive zones:** Creating collective areas for rest or discussion, which can be transformed into private spaces.
4. **Activation of circulation paths and transitional spaces:** Utilizing hallways, entry lobbies, and areas adjacent to staircases for social interactions and informal learning.

6.2. Versatility includes:

1. **Spatial fluidity:** Ensuring ease of rearrangement (e.g., using lightweight and movable partitions).
2. **Transparency:** Allowing visibility between adjacent spaces through glass walls or low partitions.
3. **Multi-functionality:** Using classrooms flexibly with movable furniture and partitions for different activities at different times.

6.3. Adaptability includes:

1. **Indoor-outdoor connection:** Allowing control over access to courtyards or external areas through movable walls or adjustable ceilings during different seasons or times of day.
2. **Positional strategies:** Designing collective spaces for easy access to various facilities (e.g., restrooms, water fountains, cafeteria, classrooms, and staff rooms).

Implementing these strategies enables the design of flexible walls that enhance the sense of belonging among high school students, fostering stronger engagement and attachment to the school environment.

Declaration

We acknowledge that we used ChatGPT to enhance the academic writing of our manuscript while ensuring the originality and integrity of our work.

Transparency Statement

The data supporting this study are available upon reasonable request to the corresponding author, subject to ethical and confidentiality considerations.

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Declaration of Interest

The authors declare that they have no competing interests.

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