Original Article

Determinants of Large Lecture Hall Seating Preferences and Academic Performance in an All-Female Medical College: Development of the Socio-spatial Synergy Zone Concept through a Mixed-Methods Study

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ABSTRACT

Background: Seating choice in large lecture halls reflects a complex interplay of environmental, psychosocial, and behavioral factors and has been linked to student engagement and academic performance. However, evidence from all-female medical institutions remains limited. Objective of this study was to investigate the determinants of seating preferences among female medical students and to explore their association with academic performance in an all-female public-sector medical college in Central Punjab.

Participants and Methods: This convergent parallel mixed-methods study was conducted at Fatima Jinnah Medical College, Lahore, from July 2023 to June 2024. All consenting students from first to final year with ≥75% attendance were included. A validated Classroom Seating Preference and Participation Questionnaire comprising Likert scale items for quantitative and open-ended question for qualitative component was used as data collection tool. Purposive quota sampling was used. Questionnaire was administered at the end of scheduled lectures. Seating preferences were categorized into front, middle, and back zones. Academic performance was assessed using self-reported examination scores. Quantitative data was analyzed using descriptive and inferential statistics. Following preliminary analysis of open-ended responses, three focus group discussions were held. Qualitative data underwent thematic analysis. Findings were integrated through methodological triangulation.

Results: Of 1,200 eligible participants, 948 (79%) completed the study. Seating preferences differed significantly across academic years ($p<0.001$). First-year students preferred front zone, whereas middle zone dominated from second to final year. Five factors independently determined seat selection ($p<0.001$): visibility, peer proximity, psychosocial consideration, environmental comfort, and habitual seating behavior. Psychosocial and environmental factors became increasingly important determinants with academic progression. Academic performance showed a zonal transition; front-zone students achieving the highest scores in first year (78 ± 6%) while middle-zone students performed better in subsequent years (74–77%; $p<0.005$). Qualitative findings supported shift from dependence on teacher proximity toward peer affiliation, psychosocial comfort, and strategic autonomy.

Conclusion: Seating preferences evolve with academic progression and are determined by visibility, psychosocial comfort, peer affiliation, environmental factors, and habitual seating behavior. Middle zone of large lecture halls in all-female medical learning environment serves as socio-spatial synergy zone and was associated with better academic performance in senior academic years.

Keywords: Undergraduate; Female; Medical; Learning environment; Large lecture hall; Seating zone preference; Academic performance; Socio-spatial synergy

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INTRODUCTION

Lecture-based teaching is one of the major components of undergraduate medical education, particularly in institutions with large student cohorts. Lecture halls remain the most practical and suitable instructional strategy for delivering the core curricular content.[1] Environmental psychology focuses on cognitive processes including environmental perception, spatial cognition, personality, along with the management of personal and social space, human interactions and learning dynamics.[2] Studies have shown that students tend to choose the same territorial seats over time in the institutional classrooms and

individual students prefer to remain in a relatively small territory within a classroom.[3,4] This spatial choice is considered to help students to better control their learning environment by establishing a personal territory in the lecture hall earlier in the course of study and avoid renegotiating the seating arrangement with their peers each time, thus facilitating achievement of their educational goals with minimal interference. Educational research on the relationship between classroom seating zones and student performance in large lecture halls have demonstrated the effects of seating zones on students' attitudes, attention, engagement with teachers, participation, motivation, educational achievements and outcomes.[2-6] Medical students seated in the action seats (front and centre) or the high-interaction zones (sitting within the triangle in the front of the class next to the teacher) demonstrate better academic performance and less absenteeism.[3,4] Seating distance and spatial orientation affect learners' engagement. Increased physical distance from the instructor and sitting in back rows have been reported to be associated with lower learning performance and educational achievements as compared to those sitting in the middle or front zones of large classrooms.[2-7] Furthermore, more motivated and engaged students tend to sit in the middle and front of the classroom, whereas weak students prefer to sit in the back.[5-7] The specific seating preference in various classroom zones may even lead teachers to deal students in potentially preferential ways. A relatively prejudicial ignorant attitude for students sitting in the back zone of lecture hall may affect transfer of learning, an effect known as the "Pygmalion" effect.[6] Collectively, the available evidence suggests that seat selection reflects a complex interplay of academic motivation, environmental conditions, and psychosocial dynamics. However, current evidence is derived predominantly from mixed-gender educational settings, with limited data available from public-sector medical institutions in Southeast Asia and Pakistan.[2,4-10] Fatima Jinnah Medical College is an exclusively female public-sector medical institution affiliated with Fatima Jinnah Medical University Lahore, in the Central Punjab of Pakistan. The College provides a unique educational setting by annually admitting female students from diverse geographical, cultural, and linguistic backgrounds, including open-merit students from Punjab, quota-based admissions from Balochistan, Azad Jammu and Kashmir (AJK), Gilgit-Baltistan (GB), and overseas international student cohort as well as special reserved quota for students with disabilities. This diversity creates a distinct educational context in which seating behavior may reflect physical environmental influences, academic intent, peer affiliation, anxiety regulation, personality traits, psychosocial and cultural factors, clinical workload, and examination pressures within an all-female educational environment. The research question guiding this study was: What factors determine classroom seat selection among undergraduate female medical students in a large lecture hall? The objective of this study was to investigate the determinants of seating location preferences among female medical students in large lecture halls and their relationship with academic performance, while elucidating the contextual factors underlying these choices through a concurrent mixed-methods approach.

PARTICIPANTS AND METHODS

This convergent parallel mixed-methods cross-sectional study was conducted between July 2023 and June 2024 by the Surgical Unit I, Department of Surgery in collaboration with the Department of Medical Education of Fatima Jinnah Medical College (FJMC) Lahore. Ethical approval was obtained from the Institutional Review Board and participation was voluntary. FJMC is an all-female public sector medical college in Lahore affiliated with Fatima Jinnah Medical University Lahore Pakistan. All enrolled MBBS students (local and international) with a minimum of 75% attendance in the current academic session during the study period and willing to participate were included in the study. Students who declined to provide consent, were absent on the day of data collection, or submitted incomplete questionnaires were excluded. Students with documented visual or hearing impairments or other disability that mandated sitting in the front rows were also excluded to avoid confounding "preference" with "necessity".[11] Using 95% confidence level, 5% margin of error, and an assumed response distribution of 50%, the minimum required sample size for a population of 1,530 students was calculated to be approximately 307 participants with at least 62 students from each academic year.[11,12] However, to increase the statistical reliability and generalizability, an expected 75% response rate, considering some drop outs due to incomplete responses, withdrawal after consent, and other reasons, total 1200 students (240 per class) fulfilling the selection criteria were recruited. A census-based sampling approach was used for quantitative component in which all eligible MBBS students were invited to participate. For the qualitative inquiry, purposive sampling was used to ensure representation from different academic years, representing all seating zones, and diverse cultural and geographical backgrounds, including students from Punjab, Azad Jammu and Kashmir (AJK), Balochistan, Gilgit-Baltistan (GB), and the international student cohort.[12] For the quantitative questionnaire, specific targets were set to include all available and willing interprovincial and overseas students alongside the Punjab-merit majority, aiming for a 75% response rate in each academic year to keep the data

statistically balanced and cover their unique cultural and linguistic diversity (purpose quota sampling). For the qualitative component, willing students from these diverse backgrounds and different seating zones and rows were intentionally invited to participate in the focus groups. This deliberate sampling facilitated a true cross-section of the student cohort, ensuring that the unique cultural and linguistic perspectives of international and interprovincial students were not lost among the larger local population. The lecture halls used for teaching were large (lecture hall with more than eight rows), accommodating 302 students and comprised 9 to 12 rows across different academic years.[13] Seating was divided into two columns of progressively increasing row capacity, arranged on a gentle slope separated by a central aisle and side pathways on each side. A 3 to 4 meters wide board and/or screen was placed on the stage in the front of the class 2-3 m from the first row. For the purpose of this study, seating locations were categorized in three zones based on proximity to the teacher and teaching area: rows 1–3 being closest to teacher were designated as the front zone, rows 4–7 as the middle, and rows 8 onwards as the back zone. This division is commonly used in educational research to study student engagement, participation, and academic outcomes in lecture-based teaching environments.[2,4,13-15] The lectures were delivered in interactive format by senior faculty members including professors, associate professors, assistant professors, senior registrars and senior demonstrators using audiovisual aids appropriate to the content and preference of the teacher. Lecture from first to fourth year were of 45 minutes duration, whereas those for final year were of 60 minutes duration. The students entered the room from the front door and were free to select their seats when they walked into the classroom. Students who entered the room early were therefore more likely to have a seat of their choice than were students who entered closer to or after the lecture started. Visibility was defined as students' perceived clarity of viewing lecture materials, including slides and board content, influenced by lighting conditions, brightness, and glare, from their seating location.[15-18] Habitual seating behavior was characterized operationally as the consistent, spatial persistence of a student within a specific lecture hall zone (Front, Middle, or Back) during most lectures (>70%) in the same classroom, driven by an adaptive balance of physical clarity, psychosocial comfort, and peer proximity.[3,4,15,16] This signified that students often develop stable seating patterns influenced by personality trait, individual learning preferences and engagement patterns. This was quantified through participants' self-reported usual seating location during lectures. Students were classified into front, middle, or back seating zones according to the zone they reported occupying most frequently, and this categorical variable was analyzed quantitatively using frequencies, percentages, and comparisons across academic years and other study variables. Classroom engagement was defined as the degree of student involvement in lectures measured through self-reported behaviors such as attentiveness, notes taking, active interaction, asking questions, and involving in discussions.[16,17] For the purposes of this study, task-related peer collaboration was referred to brief academic exchanges between nearby students aimed at clarifying, confirming, or reinforcing lecture content.[19,20] Academic achievement, as an objective indicator of academic success, was defined as the student's most recent summative assessment scores, including mid-term tests and professional examinations. Mid-term test results were used for first- and final-year students, whereas professional examination results were used for second, third, and fourth year students. All self-reported scores were cross-checked from official institutional records and converted to percentage values (<50%, 50–69%, 70–79%, ≥80%) to allow comparison across cohorts and was expressed as mean scores with standard deviation, indicating both the average performance and variability within each academic year.[4,10,21,22] Quantitative data was collected using a structured Classroom Seating Preference and Participation Questionnaire (CSPPQ) adapted from published studies on classroom seating location, student engagement, and academic performance in large lecture hall environments.[2,4,12,14,21,22] The questionnaire evaluated environmental, social, psychological and academic factors influencing seat selection and comprised of five sections: demographic and academic information, seating location in the lecture hall, factors influencing seat selection, classroom engagement, and perceived academic impact (students' personal belief about how the seating location in the lecture hall affects their learning, motivation, and examination performance). The items were measured using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Preferred seating location and corresponding seating zone were determined from students' self-reported row and column positions most frequently occupied during lectures. Items assessing determinants of seat selection included visibility of the teacher and teaching materials, habitual seating preferences, peer affiliation, psychosocial influences, opportunities for teacher interaction, and contextual factors relevant to medical education, including examination relevance of the topic, lectures delivered by potential examiners, and fatigue following overnight clinical duties. At the end of the questionnaire, students were invited to respond to the open-ended question: "Students choose different seating locations for different reasons. Please describe why you usually prefer a particular row or location during lectures and how this choice

influences your learning experience". The question was designed to elicit personal reflections on the academic, environmental, behavioral, and psychosocial factors determining seating preferences within the lecture hall. Content validity of the questionnaire was ensured through expert review by three medical educationists. The instrument was pilot tested on 30 medical students each from first to final year to ensure clarity and feasibility. Internal consistency of the Likert-scale items was assessed using Cronbach's alpha, which established good reliability (α=0.82). To ensure maximum participation, the questionnaire was administered immediately after scheduled teaching session when students were already assembled in the lecture hall designated for each academic year. To minimize response fatigue, the questionnaire was designed to be concise and required approximately 8–10 minutes to complete. To assess habitual seating behavior, participants were asked to report the row and zone they most frequently occupied during lectures rather than their seating location on the day of data collection. Before participation, students were informed about the study purpose, voluntary nature of participation, confidentiality of responses, and their right to decline or withdraw without academic consequences. Questionnaire was distributed in paper format to willing participants at the end of the lecture, and anonymous completion and submission were considered implied informed consent. To protect privacy, responses were recorded using unique numerical codes instead of names or roll numbers. Adequate time was provided for questionnaire completion, and participants were encouraged to respond independently and thoughtfully at their own pace and based on their usual experiences. Questionnaires were collected immediately after completion to minimize missing data and non-response. Responses were subsequently reviewed for completeness before inclusion in the analysis. For geographical mapping, the student mentioned their side (right or left column), row and seating location in the row. To minimize the effects of potential confounding factors, including academic year, lecture attendance, arrival time to the lecture hall, and lecture-related variables, data was collected under comparable teaching conditions in the designated lecture halls. Relevant variables were subsequently considered during stratified and multivariable analyses using appropriate statistical methods. Quantitative data was entered and analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data, with frequencies and percentages reported for categorical variables and means with standard deviations calculated for composite scores of questionnaire domains related to visibility, psychosocial comfort, peer affiliation, environmental comfort, and seating preferences. The internal consistency of questionnaire domains was assessed using Cronbach's alpha. Associations between seating location and categorical variables, including academic year and lecture attendance, were examined using the Chi-square test. Differences in questionnaire scores across seating zones were analyzed using the Kruskal–Wallis test. One-way ANOVA was used to compare mean academic performance across seating zones and academic years, with effect sizes reported as eta-squared (η^2). Spearman's rank correlation was used to examine relationships between factors influencing seating preference and student engagement. Multivariate regression analysis was performed to identify independent predictors of seating preference while adjusting for potential confounding variables, including academic year and lecture attendance. Statistical significance was set at $p<0.05$. For integration of findings, responses to the open-ended question were subjected to preliminary thematic analysis within 72 hours of questionnaire collection. This quick review of reflection facilitated capturing the frequent and recurring reasons and factors for seat selection. By identifying the main themes from the written reflections, the broader survey data was transformed into a semi-structured focus group discussion (FDG) guide. This process ensured that the focus group prompts were not pre-determined but were instead developed from the students' own shared classroom realities. Three FGDs of 45 minutes duration each were held in the seminar room of the DME at an interval of 7 days. Each group of comprised of 25 students including five students from each academic year and representatives from the front, middle, and back rows, alongside international and interprovincial peers. The discussions were led by an unrelated senior faculty member to eliminate any perceived examiner-related hesitance and to encourage students to speak freely about environmental or teaching stressors. Students were informed that all discussions will be audio-recorded for research purpose only and to ensure the accuracy of their voices and comments and would be destroyed after transcription. The confidentiality during FDGs was maintained by using pseudonyms for all participants. The audio recordings were used as the primary data source for generating themes through the process of verbatim transcription. The recordings were heard multiple times to capture every spoken word, pauses, and emotional emphasis to achieve familiarization. This helped in generation of initial codes from students' dialogues. These codes were then iteratively clustered into subthemes. This identified specific patterns to be synthesized into overarching main themes which reflected the collective experience of the class and ensured that the final results were true, humanistic reflection of the students' experiences in the lecture hall. All audio recordings and

transcripts were stored on a password-protected drive, accessible only to the primary research team. To determine the relationship between seating zone and educational achievement, students were asked to report their most recent academic scores and whether they consistently selected the same seating zone, in order to determine consistency of their seating behavior and its correlation with their academic performance. First-year students reported their most recent midterm class test marks in physiology, biochemistry and anatomy, and mean of the three scores was calculated to represent overall academic performance. Students in second, third, fourth and final year reported the percentage score obtained in their most recent professional examination. The quantitative and qualitative datasets were analyzed independently and subsequently integrated during the interpretation stage to obtain a comprehensive understanding of students' seating preferences. In addition to statistical significance testing, effect sizes were calculated using eta squared (η^2) for one-way ANOVA and partial eta squared for two-way ANOVA to determine the magnitude of differences across seating zones and academic years. The effect size estimates were calculated from ANOVA sum of squares. η^2 value of 0.01 reflected small effect, 0.06 moderate effect, and 0.14 a large effect. The rigor of qualitative data was ensured through credibility (verbatim transcription and repeated review), dependability (systematic coding), and methodological triangulation of questionnaire narratives, focus group discussions, and quantitative findings.

RESULTS

Out of a total student population of 1,200 (240 per academic year), an overall response rate of 79% (N=948) was obtained. The mean age of the final study participants was 20.5+ 1.8 years (range 16 to 24 years). Participation was consistent across all five years, with minor variations: 187 (77.9%) respondents in the first year, 194 (80.8%) in 2nd Year, 185 (77.1%) in 3rd year, and 192 (80%) and 190 (79.2%) students in 4th and final year, respectively. Total 252 (21%) respondents were excluded due to either incomplete or inconsistent data (237 participants), whereas 15 students opted out of the study without providing any specific reason. The distribution of seating preferences across academic years is shown in Table 1. A significant association was observed between academic year and seating preference ($p<0.001$). Front zone was dominant in first year, whereas increasingly middle-zone preference was observed in Years 2–4. Final-year students demonstrated a mixed middle and back zone pattern, reflecting a transition toward more academically strategic and professionally autonomous seating behavior. Table 2 explains this observation from qualitative perspective. Correlating the quantitative and qualitative components, the "front zone" in the early years is more preferred for academic performance and achievements. However, the "middle zone" gains dominance in the clinical years for strategic learning and greater self-directed academic engagement. Interpreting these findings, the subtle migration towards back zone with increasing clinical seniority in final year seems to be more a symbolic attitude signifying growing confidence and an evolving professional identity. Table 3 summarizes stratified data for the significant environmental and psychosocial factors influencing the seating zone preferences. The table shows statistically significant variation in environmental, social (connections and avoidance), and behavioral factors influencing seating preference across academic years ($p<0.001$). Front-zone preference in Year 1 is primarily driven by high visibility, lighting adjustment and proximity (4.82 ± 0.3) and lighting requirements, reflecting the need for clear access to instructional material. In Years 2 and 3, a shift toward middle-zone seating is observed, where peak peer interaction (4.65 ± 0.4; 4.40 ± 0.6), combined with adequate visibility, supports enhanced engagement. This middle-zone preference persists up to Year 4, suggesting that a balance between visibility and peer interaction represents an optimal learning environment. In the final year, a mixed middle–back seating pattern emerges, reflecting greater flexibility in seating choice. Effect size analysis confirmed a large effect for visibility ($\eta^2 > 0.14$) and moderate effects for peer proximity ($\eta^2 \approx 0.08–0.12$), environmental comfort ($\eta^2 \approx 0.06–0.10$), and habitual seating behavior ($\eta^2 \approx 0.07–0.11$). The findings suggest that peer grouping, psychosocial safety, and habitual seating patterns contribute significantly to seating selection, particularly in an all-female context.

Table 1: Seating zone preferences by academic year (N=948)

Academic Year (No. of students)	Front Rows N (%)	Middle Rows N (%)	Back Rows N (%)	p-value*
First year (187)	80 (42.8%)	75 (40.1%)	32 (17.1%)	< 0.001
Second year (194)	55 (28.4%)	105 (54.1%)	34 (17.5%)	
Third year (185)	40 (21.6%)	100 (54.1%)	45 (24.3%)	
Fourth year (192)	38 (19.8%)	110 (57.3%)	44 (22.9%)	
Final year (190)	40 (21.0%)	78 (41.0%)	72 (37.9%)	
Total (948)	**255**	**459**	**234**	

***** Calculated using Pearson's Chi-square test for independence

Table 2: Narrative correlation with quantitative observations

Academic Year	Primary Seating Trend	Representative Verbatims
Year 1	**Front Row dominance (Instructional proximity)**	1. "I always come early to get almost exact location in the first two rows. If I do not find my usual spot with a clear view of the teacher and slides, I feel disconnected and lose my focus on the new terminologies. Moreover, I prefer to be visible as teacher could be my examiner." 2. "By sitting in the first three rows, I see every gesture, hear every word, sometimes even understanding with lip reading even when I have difficulty in following the language or difficult and new terms." 3. "As a foreigner, sitting in the front helps me clearly hear and understand the teacher, especially when the language and accent is different."
Year 2	**Spatial Stabilization, Territoriality and Geographical consolidation**	1. "I have now established my 'favourite' spot. Sitting with my batchmates and like-minded friends in the middle help me whisper to clarify points without disrupting the whole class." 2. "I prefer the middle because to me it is the best balance. I am close enough to remain engaged and far enough to be safe from the teacher's gaze and being called on unexpectedly; at the same time, I remain engaged without any fear." 3. "As international student, I still prefer to sit near the front, but not necessarily in the first row, but more based on where I can both see clearly and sit with classmates who help me if I miss something, we can actually learn together."
Year 3	**Seating Adaptation and Engagement**	1. "Middle zone seems to be a relief after being involved more and more in clinical rotations. It is less about rote learning everything being taught in the lecture and more about absorbing what's relevant in clinical context, so I find it better to see and learn what I need without being perceived by the teacher that I am not interested." 2. "I have started moving towards fourth or fifth row because I often need to prepare for my ward or upcoming class tests, and I do not want to make a scene by being identified as not listening to the lecture, in fact the middle is my Sweet Spot." 3. "Being a foreigner, now I prefer the middle rows because I can follow the lecture better and may discuss new concepts with my friends during interactive sessions. I found that middle rows seem to work best for me academically."
Year 4	**Strategic Positioning and Functional consistency**	1. "Sitting somewhere in the middle rows make me feel more comfortable professionally now. Unlike a high school classroom, this area is helpful in being more collaborative. I have my own learning space where we can filter the contextual important information, I don't need to be in the front for that." 2. "In the middle, I am close enough to see the slides and at the same time surrounded by my friends. I feel it is the best spot for group learning." 3. Being an international student, at this stage, I sit where I feel comfortable, I believe my performance doesn't depend much on seat location now, but I still somehow tend to avoid very far corners and front rows, nothing special."
Year 5	**Environmental habituation, Comfort, Strategic learning, and Spatial autonomy**	1. "The middle rows work best for me most of the time, but I may choose the back seats strategically when I am already familiar with the topic or need a less distracting space." 2. "As a final-year student, I do not feel dependent on sitting near the front; I usually prefer the middle area and occasionally select the back rows according to the nature of the lecture." 3. "Oh, I sometimes prefer to sit in the back because I'm exhausted from on calls. It gives me the freedom to listen intently while having the physical space to just breathe." 4. "Being foreigner; No; I do not consider myself as an alien anymore. I usually prefer to sit in middle or back rows with my batchmates. I think, seat location does not significantly affect my learning anymore; it's more about my own preparation and comfort. Hectic clinical rotations, night duties, upcoming class and ward tests and internal assessment become more preference at this stage."

Table 4 summarizes the academic achievement correlated with academic year-wise seating zones. The table demonstrates statistically significant differences in academic performance and achievement across seating zones within each academic year. The ANOVA (p values) and F-statistics reflect the variation in academic performance across seating zones within each academic year is significantly greater than the variability among students within the same zone, supporting the presence of meaningful differences between seating groups. In Year 1, students seated in the front zone achieved the highest scores (78 ± 6), significantly outperforming middle and back zones. From Year 2 onward, the middle zone consistently showed higher academic performance (77 ± 6; 76 ± 7; 74 ± 8; 75 ± 7). The post hoc analysis confirms the differences to be significant differences ($p < 0.05$). In contrast, the back zone showed comparatively lower performance across all years. Overall, these findings indicate a shift from front-zone advantage in initial academic years to a statistically significant middle-zone improvement with academic seniority. This reflects that a balance between visibility, environmental comfort and peer interaction provides the most favorable learning conditions for academic performance. Effect size estimates indicated a moderate effect of seating zone on academic performance ($\eta^2 \approx 0.04$–0.08). Analysis for interaction between academic year and seating zone also confirmed a moderate effect size (partial $\eta^2 \approx 0.06$). This reflects the influence of seating evolving

with academic progression. Table 5 summarizes the concurrence of quantitative factors influencing the academic performance and supporting qualitative narratives. Academic performance differed significantly across seating zones within each academic year (one-way ANOVA, p≤0.005). First-year students performed best in the front zone, while middle-zone association with academic achievement became significant from second year onward. However, strength of this association decreased with academic seniority, despite remaining statistically significant (F = 6.45, p<0.001). This reflects the effect of seating zone on academic performance with clinical progression and seniority. Concurrent qualitative data supported this trend, demonstrating a significant shift from dependence on visibility and teacher proximity to greater professional and academic autonomy and self-regulated strategic learning.

DISCUSSION

The lecture hall is a dynamic educational environment in which learning behaviors are shaped by spatial, social, and instructional factors. Students' seating selection and location are usually influenced by seating arrangement provided to them. Various seating arrangements, like rows and columns, semicircle, u-shape, clusters and pairs have been used according to teaching requirements and learning activities.[4,5,13,15] In Asian countries, rows and columns remain the most common arrangement, especially for large lecture hall setting in medical institutes.[4,7,8,10,23-25] Present study, conducted on a large and demographically stable cohort of 948 female medical students with mean age of 20.5 ± 1.8 years, provides some evidence on the factors influencing seat selection by female undergraduate medical students during traditional lectures in large lecture halls in an all-female medical college. Comparable sample consistency has been emphasized in recent higher education research as essential for reliable behavioral interpretation.[3,19,25] Selection of seating location by undergraduate medical students for traditional lectures in large lecture halls is usually not merely a random act but is a reflection of their academic motivation, environmental perception, and psychosocial behaviors and personality traits.[4,26-28] In an all-female public sector medical institution, these choices are further influenced by students' personality traits and gender-specific learning approaches to anxiety management, noticeability and visibility, complexity of content, teachers' attitudes, and collaborative learning styles and predicted academic performance.[2,4,26-29]

Table 3: Significant environmental and social factors stratified by academic year (N=948)

Academic Year (No. of students)	Primary Seating Zone	Visibility (Mean ± SD)	Environmental Factors# (Mean ± SD)	Lighting/Glare (Mean ± SD)	Peer Proximity (Mean ± SD)	HSB* (Mean ± SD)
First year (187)	Front	4.82 ± 0.3	2.90 ± 1.1	4.45 ± 0.5	2.85 ± 1.2	3.10 ± 1.0
Second year (194)	Middle	3.95 ± 0.6	3.25 ± 0.9	3.70 ± 0.8	4.65 ± 0.4	3.75 ± 0.8
Third year (185)	Middle	3.75 ± 0.7	3.60 ± 0.8	3.55 ± 0.9	4.40 ± 0.6	4.05 ± 0.7
Fourth year (192)	Middle	3.10 ± 0.9	4.10 ± 0.6	3.30 ± 1.0	4.20 ± 0.7	4.25 ± 0.6
Final year (190)	Middle and Back (Mixed)	2.70 ± 1.1	4.35 ± 0.5	3.00 ± 1.2	4.00 ± 0.8	4.45 ± 0.5
F-statistic		52.40	24.10	18.95	27.60	22.10
p-value**		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
η^2 (Effect size)***		0.18	0.09	0.07	0.11	0.10

include thermal comfort, illumination, lighting and glare, ease of movement

*HSB – Habitual Seating Behavior

**p-values derived from one-way ANOVA across academic years

***represents the proportion of variance in each factor explained by academic year; calculated from one-way ANOVA with ratio of between-group sum of squares to total sum of squares and from the f-value.

Table 4: Academic achievement across seating zones by academic year (N = 948)

Academic Year (No. of students)	Front Zone (Mean ± SD)	Middle Zone (Mean ± SD)	Back Zone (Mean ± SD)	F-value*	p-value**	Primary Zone
First year (187)	78 ± 6^a	76 ± 7^b	74 ± 8^c	8.12	<0.001	Front
Second year (194)	75 ± 7^b	77 ± 6^a	73 ± 8^c	7.45	<0.001	Middle
Third year (185)	74 ± 8^b	76 ± 7^a	73 ± 8^c	6.98	<0.001	Middle
Fourth year (192)	72 ± 9^c	74 ± 8^a	73 ± 8^b	5.76	0.003	Middle
Final year (190)	73 ± 8^b	75 ± 7^a	74 ± 7^b	5.21	0.005	Middle
Overall				6.45	<0.001	
η^2 (Effect Size)	—	—	—	0.04–0.08***		

Values are expressed as Mean ± SD. Superscripts a, b, and c within the same row indicate statistically significant differences between seating zones (Tukey post hoc test, p < 0.05).

*F-value within academic year is derived from one-way ANOVA, whereas overall F value is obtained by two-way ANOVA

**p-value derived from one-way ANOVA within each academic year; overall interaction tested using two-way ANOVA

***derived from one-way ANOVA and represents the effect size of seating zone on academic performance across academic years

Table 5: Quantitative and qualitative concurrence of factors influencing the seating preference and academic performance (N = 948)

Academic Year (No. of students)	Primary Seating Zone	Academic Performance (Mean ± SD)	Significant Quantitative Factors (Mean ± SD)	F-value*	p-value**	Representative Verbatim (Qualitative)	Concurrent Interpretation
First year (187)	Front	78 ± 6	Middle:76 ± 7 Back: 74 ± 8 Visibility: 4.82 ± 0.3 Lighting: 4.45 ± 0.5 Thermal: 2.90 ± 1.1	8.12	<0.001	"When I sit in front, I can hear clearly, see the slides properly, and I stay focused." "Being in front keeps me attentive because the teacher can notice me if I lose attention."	Strong concurrence: Higher scores in front zone reflect audibility, visibility and teacher proximity affecting learning and performance.
Second year (194)	Middle	77 ± 6	Front: 75 ± 7 Back: 73 ± 8 Visibility: 3.95 ± 0.6 Peer proximity: 4.65 ± 0.4 Thermal: 3.25 ± 0.9	7.45	<0.001	"Middle rows are better, I can see and hear clearly and feel relaxed with my friends."	Concurrence: Shift toward middle zone indicates balance between visibility and psychosocial comfort.
Third year (185)	Middle	76 ± 7	Front: 74 ± 8 Back: 73 ± 8 Visibility: 3.75 ± 0.7 Peer proximity: 4.40 ± 0.6 Thermal: 3.60 ± 0.8	6.98	<0.001	"Front is more stressful and back is more distracting. I think middle is the best, I stay comfortable, focussed and engaged, being among my groupmates."	Strong concurrence: Optimal learning occurs in balanced seating environment, safety, and peer support leading to high academic performance.
Fourth year (192)	Middle	73 ± 8	Back: 73 ± 8 Front: 72 ± 9 Thermal: 4.15 ± 0.6 Peer proximity: 4.25 ± 0.7 Visibility: 2.80 ± 1.0	5.76	0.003	"I do not need to seek a place, just have developed the habit of being at my own seat in the fourth row from very beginning." "Seating does not matter, I can focus on examination-related important information, though being in the middle among my peers gives me more psychological safety."	Moderate concurrence: Reduced performance gap reflects increasing academic independence. Increasing autonomy, psychosocial factors and habitual seating behavior dominate.
Final year (190)	Middle	74 ± 7	Back: 74 ± 7; Front: 73 ± 8 Thermal: 4.35 ± 0.5 Peer proximity: 3.90 ± 0.9 Visibility: 2.45 ± 1.2	5.21	0.005	"Seating doesn't affect me much now, but being in the middle is more comfortable." "I can follow the lecture from anywhere now, but middle helps me concentrate and interact better."	Partial concurrence: Minimal differences suggest seating location becomes less influential with increasing academic and clinical experience. Strategic learning becoming more evident.
Overall***	—	—	—	5.92	<0.001	"Earlier I needed more front rows, now it doesn't matter much."	Significant interaction indicates that middle zone reflects optimal balance of factors affecting academic progression and performance. However, there is gradual transition from environment to strategic and self-regulated learning.

* Tukey post hoc test used for pairwise comparison.
**p-values derived from one-way ANOVA comparing academic performance across seating zones within each academic year
***Overall F and p-values represent the interaction effect from two-way ANOVA assessing seating zone × academic year

The traditional "Action Zone" theories describe that the front rows and proximity to the instructor are strong predictors of academic performance.[2,15,30] Student proximity to teacher and peer student groups are known to positively affect student engagement and learning satisfaction in the lecture room.[29,31,32] However, the statistically significant association between academic year and seating preference ($p<0.001$) found in this study reflects that seating behavior is not static but evolves with academic and clinical progression in medical students. These observations suggest that learning behaviors within this all-female medical institute involve a dynamic balance between proximity, visual clarity, clinical contextuality, peer affiliation, psychosocial comfort, and individual personality traits that evolves with academic seniority. Previous studies, although conducted largely in mixed-gender settings, provide support for several observations identified among students in the present cohort.[3,4,27,29,32,33] Previous research demonstrated that when undergraduate students were frequently moved from one place to another, their learning satisfaction and academic productivity were significantly affected in both free and assigned seating arrangements.[32-34] The relationship between seating proximity and student motivation, engagement, and academic performance appears complex and may vary according to individual preferences, classroom environment, and learning context.[5,6,22] Although social interactions, including social connections and avoidance, peers and group interaction, have demonstrated a positive effect on students' engagement and encourage active learning, there remains a risk of distracting non-academic interactions. Teachers may specifically assign seats to control frequently evident distracting peer interactions. However, this is reported to have a negative influence on the future learning and academic performance.[5,29,32,34] Social learning theory states that people learn by observing and imitating others.[35] Based on this theory, medical students, while in psychosocial proximity comfort, learn effectively by observing and interacting with their peers and group which in turn positively affects their engagement, motivation and academic performance.[32,35,36] The concurrence of quantitative and qualitative findings in the present study reflects a subtle but clear, evolution of learning behavior of medical students in an all-female undergraduate medical institute. The students keep changing their seating preferences in large lecture halls from first through final year. The initial reliance on the front zone in the first year (42.8%) shifted to a noticeable preference for the middle zone from second year onwards (57.3% in 4th year), eventually stabilizing into a mixed middle-back arrangement by the final year. This shift in seat preference is well explained by the concurrent qualitative narratives: the early preference for individual audiovisual clarity and teacher proximity replaced with a desire for more peer collaboration and professional autonomy with seniority. Although the gap between middle- and back-zone preferences was considerably reduced in the final year, the middle zone continued to be the most preferred seating location (41.0% vs. 37.9%) for final year students as well. These observations are well aligned previous studies describing early-stage undergraduate cohorts frequently preferring front and central seating locations to optimize slide visibility, minimize distractions, and maximize direct focus on unfamiliar terminology.[2,4,5,25,27] The consistent spatial selection of middle seating zone from second year onward suggests a learning adaptation by establishing a habitual seating location based on psychosocial comfort. The peer-based territorial selection of this 'socio-spatial synergy zone' maintains motivation, builds confidence and fosters collaborative learning among medical students.[3,27,29,32,36] The progression of academic outcomes and achievements across the seating zones in this study demonstrates that the middle rows become a purposeful and intentional preferred zone, so called 'socio-spatial synergy zone', for medical students as they advance in educational years. While classical classroom models suggest that physical proximity to the instructor is the primary driver of student engagement and achievement, the findings in this all-female medical cohort indicate that the educational advantage of the front zone actually diminishes with academic seniority and psychosocial factors and clinical contextuality become predominant determinants of seating preference during lectures in large lecture halls.[2,3,25,28,29,33] The significantly higher scores observed in the middle rows from the second year onward in present study support this spatial adaptation affected by increasing clinical exposure, rotations, night duties, and changing learning habits. The 'socio-spatial synergy zone' offers a functional balance offering optimal auditory and visual engagement while providing a psychologically comfortable distance from direct teacher surveillance to allow for purposeful peer interaction when required leading to an academically mature self-regulated learning behavior. The back rows in this study represent a very minor fraction of the data, showing a lower occupancy tendency in the initial years but relatively consistent lower performance across all academic years. This observation is consistent with other studies which report back zones to be frequently associated with higher absenteeism, lower performance, and more passive learning behaviors.[5,6,13,37] Whereas previous studies relate back zone seat selection with lower academic motivation, the qualitative data from this study offers a completely different perspective in medical education. Qualitative narratives suggested that

some final-year students selected back-row seating not to disconnect from learning, but to comfortably manage physical exhaustion from hectic and immediate past and upcoming clinical encounters while cross-linking the lectures with real clinical contexts. As an exclusive female medical institution, this study clearly differentiates the behavioral and academic variables from the gender-based confounding factors common in mixed-gender settings. In the single gender psychosocial environment, female students deliberately choose the middle zone with academic seniority to build collaborative and peer based self-regulated learning behavior, and maintain a mutually supportive, low-stress comfortable learning environment. This observation is consistent with recent research that female students prefer peer proximity and mutual academic progression to optimize comfort within competitive professional courses.[24,25,35-39] By eliminating gender-based seating bias, this study demonstrates that seat selection during a lecture in a large lecture hall is an active, self-directed and psychosocial learning behavior used by female medical students to balance clinical workload with their academic requirements and achievements. The purposeful and strategic use of the back rows, as explained by the qualitative concurrence in this study, provides possible explanation why separate breakdowns for the back zone appear minimal or entirely absent in the multi-variate data analyses reflected in Table 3 and 5. While conventional models often equate back-row seating with academic disengagement and low performance, findings of this study revealed a purposeful, strategic utilization of the back zone by final-year medical students driven by spatial synergy.[4-6,29,37] Rather than representing learning withdrawal, this spatial habituation functions as a sophisticated, self-regulated adaptation. Within this specific lecture hall zone, senior students demonstrate a synergy between the physical environment, which offers a comfortable distance from direct instructor surveillance, and their immediate peer groups who share identical clinical pressures. This strategic territorial selection allows them to mitigate the profound physical and cognitive fatigue of demanding clinical workload while maintaining autonomous, collaborative engagement. By transforming the back zone into a strategic supportive socio-spatial synergy zone, senior medical students successfully balance rigorous training demands with personal well-being, proving that rear-zone habituation can represent a highly adaptive learning strategy rather than academic indifference In highly competitive professional programs high-achieving student cohorts naturally display a general avoidance for the back rows to avoid perceived teacher indifference or the distraction due to non-academic peer interactions, leaving these seats structurally underutilized by choice. However, given the increasingly stressful curricular demands of undergraduate medical education, senior students may use the back rows primarily as a temporary space to recover from academic and clinical fatigue rather than as a consistent seating preference. Consequently, data from this zone was relatively sparse and unevenly distributed. Conducting advanced multivariable analyses on such limited data could reduce statistical power and increase the risk of Type II errors. Therefore, the limited representation of back-zone seating in the multivariable analysis may reflect a behavioral tendency among medical students to remain closer to areas of active classroom interaction, while utilizing the back rows selectively as an adaptive response to the demands of a rigorous curriculum. Although final-year students demonstrated a mixed middle and back zone seating pattern, suggesting a shift toward more academically strategic and professionally autonomous seating behavior, the middle zone nevertheless remained the most preferred seating location in the final year as well. This observation is consistent with published evidence that more experienced medical students are less influenced by seating proximity and demonstrate greater adaptability to their learning environment than junior students.[3,4,25,29] Medical students uniquely choose to sit where they feel comfortable, physically and psychosocially. The range of learning zones that a female medical student may find in a large lecture hall is vast and choice of seating zone and location depends upon the individual personality traits, peer and friends' proximity, instructional context, academic workload, and exhaustive clinical rotations and duties. The selection of seating location in an all-female medical cohort is driven by the personality trait, desire to sit within friendship groups and where the student feels physically relieved, be that for reasons of audiovisual requirements, psychosocial safety or environmental comfort. Teachers need to keep in mind that If a medical student has chosen to sit at the back to avoid anxiety of direct teacher interaction or to get relief from academic stress and exhaustion, while remaining engaged with the instructional content at the same time, forcing her to move to the front zones may not be beneficial to achieve her active engagement.[26,29,35] Alternative strategies of engagement may be utilized while letting the student to remain seated wherever she is, unless a collective gross disruptive behavior is encountered from back zone.[5,40]

The quantitative and qualitative findings of this study support the existing literature on classroom seating behavior. Consistent with previous studies, visibility, instructor proximity, and seating location were significantly associated with student engagement and academic performance.[2,4,5,15,40-42] However, unlike most published studies conducted in mixed-gender settings that primarily emphasize the traditional "Action Zone" effect of front-row seating, the present study demonstrated a distinct

progressive shift from front-row preference in first-year students to a sustained middle zone preference combined with higher academic performance from the second year onward in all-female cohort. Qualitative findings provided the contextual explanations for this transition, revealing that in a large lecture hall the 'socio-spatial synergy zone' of middle rows facilitates collaborative learning, psychosocial safety, territorial familiarity, environmental comfort, adaptation to increasing academic and clinical workload during traditional lectures, while simultaneously maintaining higher and sustained academic achievements. The emergence of the middle zone as a 'socio-spatial synergy zone' represents a novel contribution of this study, suggesting that within an all-female medical educational environment, optimal learning is achieved not solely through proximity to the instructor but through a dynamic balance of visibility, peer affiliation, psychological comfort, self-regulated collaborative learning, and strategic academic autonomy.[2,5,27,29,32,38] These findings expand the current understanding of seating behavior and highlight the importance of contextual and gender-specific influences on learning in large lecture halls. Furthermore, the purposeful use of back zone seating by final-year students to manage exhaustive curricular demands of medical education while actively cross-referencing and contextualizing the lecture content with real patient encounters in clinical settings contradicts general higher education findings that treat rear seating as a marker of complete disengagement during lectures in large lecture halls.[6,29,32,37,38] By removing the confounding effects of mixed-gender psychosocial dynamics, these results confirm that within a highly competitive, single-gender medical program, large lecture hall spatial behavior functions as an active self-regulatory tool used by female students to optimize both academic performance and personal well-being.

This study has certain limitations. It was conducted in a single all-female public-sector medical college, which may limit the generalizability of the findings to co-educational institutions, private medical colleges, or other cultural settings. Although seating location was associated with academic performance, the cross-sectional study design may not allow conclusions about whether seating location directly affects academic achievement. Moreover, academic performance was assessed using different examinations across academic years, including mid-term class tests (first and final year) and professional examinations (second, third and fourth years), which may limit direct comparisons between cohorts.

CONCLUSIONS

Seating location in a large lecture hall reflects a purposeful and evolving learning behavior rather than a random choice. Among female medical students, seating preferences are influenced by a complex interplay of visibility, environmental comfort, psychosocial safety, collaborative peer learning, and habitual seating behavior. While the front seating zone appears preferred choice during the transition into medical college in first year, the learning behavior progressively shifts toward the middle zone with increasing academic and clinical seniority. This transition reflects a movement from reliance on teacher proximity and audiovisual clarity toward peer-affiliated, self-regulated, and strategically autonomous learning with academic progression. The middle zone emerged as a distinctive 'socio-spatial synergy zone', characterized by an optimal balance of engagement, interaction, environmental comfort, peer affiliation, and academic performance. These findings highlight seating behavior as a meaningful indicator of evolving learning needs within an all-female medical educational environment.

Author Contributions

KK: Conception & design, analysis & interpretation of data, drafting final manuscript, critical revision for important intellectual content, and final approval.
SK: Acquisition of data, compilation of results, literature search, and initial drafting of the manuscript.

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