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Assessment of outdoor spaces like corridors and courtyards in a school environment for occupant comfort

Seema Thippeswamy

Seema Thippeswamy Associate Professor,*
BMS College of Architecture, Bull Temple Road, Bengaluru 19
Bull Temple Road, Bengaluru 560019, Karnataka, India

Abstract - *School environment, specifically the architectural environment, is important to the child's development. (Dudek, 2000). A thorough planning in creating a conducive social environment for learning is important to produce students with good potential. Basically, imparting education is a mere tool for producing professional individuals rather than good individuals academically, socially, culturally, and professionally who are capable of any challenge. Even when concern is expressed for the quality of the design of school facilities other than non-classroom spaces are often the least considered or are perceived only as places of secondary importance with no direct impact on the principal goals of schools (Catling, 2005). The research focuses on the relationship between the semi open school environment and the student's behavior of three secondary schools in Pune. The findings suggest a clear relation between the physical environment and the comfort to the student behavior. By this study the relationship between the non-classroom areas like corridors, passages and courtyard spaces and the student comfort is understood well. Buildings are basically designed to keep the occupant comfortable although it is very subjective in nature, but the designed environment plays a role in occupant comfort. The variables or components which affect this designed environment are temperature, humidity, air velocity and daylight levels. The parameters used for the study are temperature, humidity, air velocity and lux levels and in an objective way the questionnaire survey is used. The learning environment as a physical environment expands from the classroom of a school building to include the outdoors and other purposeful learning places. The learning environment expands to cover both formal and informal learning places, and to integrate formal and informal learning. The design and planning of the school's external environment should give more consideration on creating a conducive environment that could foster positive social behavior. The methodology for this study opts for qualitative and quantitative survey, wherein observation survey, measurements of parameters and questionnaire survey was undertaken. The analysis for the questionnaire survey was statistically analyzed to find out the inferences*

***Key Words*: Corridor, Courtyard, Daylight, School environment, Thermal comfort**

1.INTRODUCTION

A well-maintained and safe physical environment fosters students' ability to learn, to show improved achievement scores, and to exhibit appropriate behavior. *This study revealed that they did not open or close windows, or change desk positions of their own accord, but accepted their condition and the arrangement of their classroom. The study also showed that a high number of pupils reacted actively to discomfort; therefore being able to interact with their surroundings would enhance the wellbeing of both children and adults.* (Guili, Carli, Martina , & Bella, December 2014) The study by (Pereira, Raimondo, Corgnati, & Manuel Gameiro da, June 2014) show us that *Concerning indoor air quality, focusing on CO2 concentration levels, the perceived votes reveal students' adaptation to the environment exposure.* Another study by (Astolfi, Corgnati, & Verso, 2003) *states about thermal comfort that slightly warm environments are preferred in comparison with environments corresponding to neutral thermal conditions and Visual comfort is to a large extent directly related to the quantity of light available inside the overall environment and in particular over task areas. The design and planning of the school's external environment should give more consideration on creating a conducive environment that could foster positive social behavior.* (Shuhana Shamsuddina, Hanim Bahauddin, & Norsiah Abd. Aziz, july 2012)

An example of the change of emphasis is UNESCO's definition of education for the twenty-first century through four pillars: learning to know; learning to do; learning to live together; and learning to be. This holistic approach underlines the close relationship between physical and intellectual well-being, and the close interplay of emotional and cognitive learning in making the best of the brain's plasticity (see OECD 2007). According to Ash and Wells (2006), some researchers have recently begun applying learning theory based on classroom work to informal environments, and conversely research on participation in informal settings has advanced understanding of topical learning theories. The learning environment as a physical environment expands from classroom and school building to include the outdoors and other purposeful learning places, and to respond in a versatile way to the challenge of young

people's physical well-being. The learning environment as an educational and cultural environment expands to cover both formal and informal learning places, and to integrate formal and informal learning. The learning environment as a socio-emotional, fantasy-oriented and innovative environment expands schoolchildren's minds to learn (cf. Claxton 2007).

Following Awartani et al. (2008, p. 60), physical well-being refers to ''feeling comfortable with one's body and physical ability and being in a healthy physical state and a healthy physical environment''. (Kangas, 9 Nov 2020) Different alternatives may be developed for children to enhance their environmental experience, to improve their environmental consciousness, and to contribute to their learning through the information that they get from the environment. All these may also be evaluated in terms of different disciplines. In terms of education, more activities based on practice and observation of practice results must be included in the curricula, applied environmental education must be offered, outdoor classrooms must be brought into the agenda by creating suitable conditions, school gardens must be designed in such a way as to enable children to interact with the natural elements. (ACAR, 2014)

Physical environment or architecture affects learning; this has been researched with a single variable – the environmental factors such as noise ,temperature air quality ,heating ,ventilation and lighting (Higgins, Elaine, Kate, Pam, & Caroline McCaughey, January 2005) there is also part of research focuses on significance of colour, interiors and physical environment, making learning environment conducive to learning (Dudek 2001, Nair 2007)researchers and planners have demonstrated that use of daylight also increases students outcome (Tina Haghighat and Aziz Bahauddin). *Some of the most important building factors that influence learning are those that relate to control of the thermal environment, proper illumination, adequate space, availability of equipment and furnishings, especially in the subject area of science.* (Earthman, , November1998)

Considering time spent ,school environment should provide opportunities for play and learning school is also a working place and learning place if seen from spatial intelligence perspective ,physical environment indicators do matter learning place wherever children encounter with space .materials ,finishes and flexibility in space need strategic planning .so it can be concluded that more attention should be given to physical environment this plays important role in developing years of child . (Chitale & Telang) Although solid proof remains a distant goal, a picture of the environment 's role in the educational process is gradually taking shape .it is a picture that is likely to please neither those who advocates minimally decorated, no nonsense classrooms, nor those who advocates minimally decorated, no nonsense classrooms, nor those who call for softer "more humane educational settings." Carol Weinstein 1979.

ANSI/ASHRAE Standard 55-2013 defines the range of indoor thermal environmental conditions acceptable to a majority of occupants. A method of describing thermal comfort was developed by Ole Fanger and is referred to as Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD). The Predicted Mean Vote (PMV) refers to a thermal scale that runs from Cold (-3) to Hot (+3), originally developed by Fanger and later adopted as an ISO standard. The aim of the research is to evaluate the semi open spaces like corridors, passages and courtyard for comfort levels in school by understanding the comfort conditions of the semi open spaces and study the relation between the use and the comfort levels of semi open spaces.

1.1 Background

The methodology followed is qualitative & quantitative. For this research, three private schools were selected as the site case studies located in 3 different locations of Pune first located in Narhe (Case I), second located in Narhe (Case II) and the third located in Nanded city (Case III). The selection of schools was carefully done to understand the location as well as the students it caters to. All the three schools selected follow a Central Board of Secondary education system and are coeducation.

The schools were selected mainly because of their different design layout. The layout of School 1 has singly loaded corridors and corridors having direct access to the outdoor spaces. School 2 has an inward-looking plan with an open courtyard in between with the singly loaded corridors overlooking the courtyard. School 3 is also an inward-looking plan bounded by the classroom spaces around with doubly loaded corridors with classroom spaces on either side. All three schools have semi-open areas like corridors and courtyard spaces used by the students. The study included the following firstly observation of the school environment to identify the semi open spaces and understanding their usability proceeded by collecting Primary data through questionnaire, interview and measurements for temperature, humidity, air velocity for the semi open spaces. Finally subjective evaluation of Questionnaire and interview objective evaluation of the measurement data.

1.2 Research methodology

The Research has adopted three techniques like observational survey, thermal and daylight measurements & questionnaire survey Students involved in the study were from standard fifth to tenth since they are mature enough to understand the questionnaire better as compared to lower classes as they are the ones who use these spaces more because they are free to use the spaces

unlike the lower standards who are restricted to use the semi open spaces.

The selection of classrooms to conduct the questionnaire survey was also done based on the orientation of the classroom and the corridors. Students from all forms of background were involved in the questionnaire. All Students of a particular class were involved in a class from one division only fifth to tenth classes in each school. These respondents' classrooms were also selected based on orientation. Classrooms oriented on North, East, West and South became the criteria for selection. The questionnaire format had closed ended questions with multiple choice questions where the choice was restricted to one answer only. Furthermore, a few questions had more than one option to be selected where the student could choose more than one answer. In total 680 students from 3 schools were involved in the survey out of which 450 were analyzed for the survey and the rest went as absent and incomplete. Chi square test was conducted for the questionnaire survey.

2. OBSERVATIONAL SURVEY

The observational survey in each case highlights the corridor and open space highlighted with different colors. Case I is a linear planning and set on a contoured site. The corridors are singly loaded having classrooms on one side and open to the green area on the other side. Case II has inward looking plan where all the classroom corridors overlook the central small courtyard which is used as an assembly place.

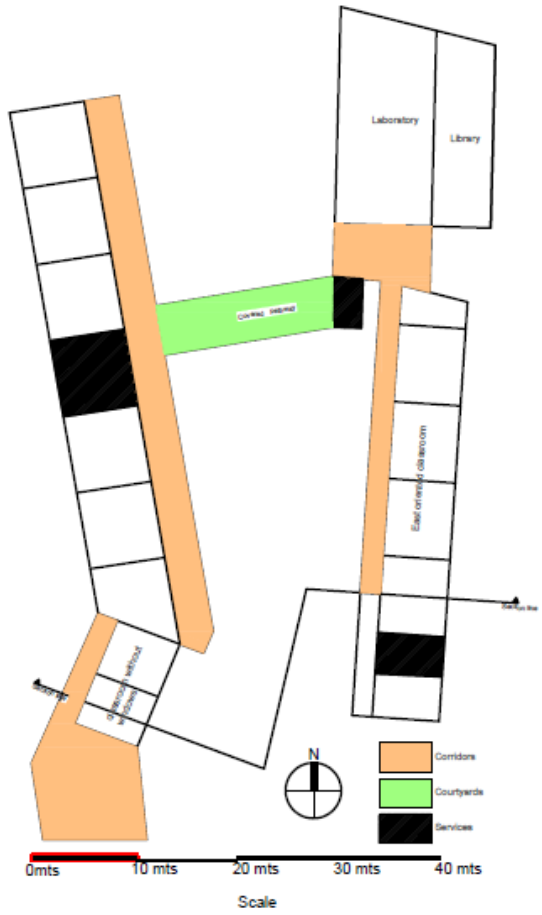


Fig. 1: Layout plan of Case I showing the corridor & courtyard. Source: Author

		
Corridor spaces used for interaction	Corridors a place to read the display	Corridors used during lunch break

Fig 2: Case I; Images showing the use of corridors and outdoor spaces for multiple activity. Source: Author

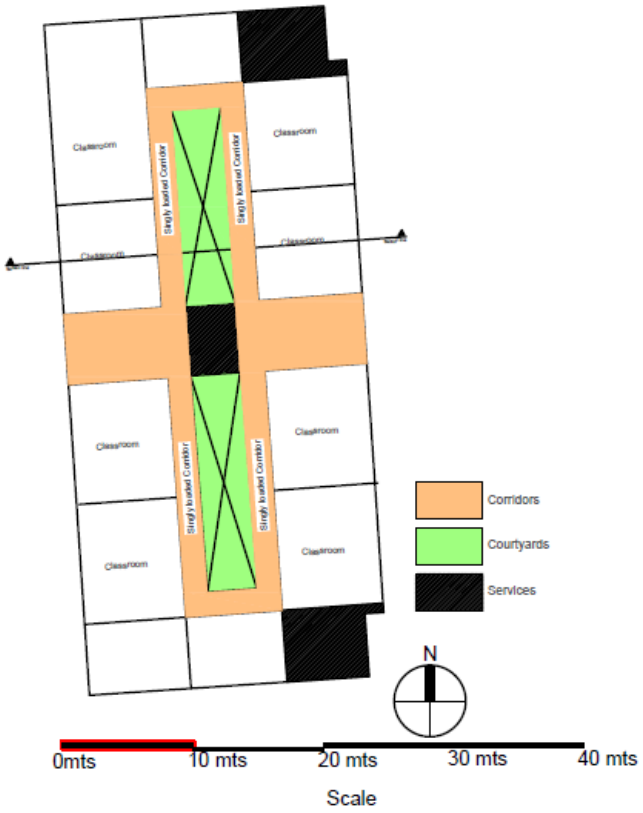


Fig. 3: Layout plan of Case II showing the corridor & courtyard. Source: Author

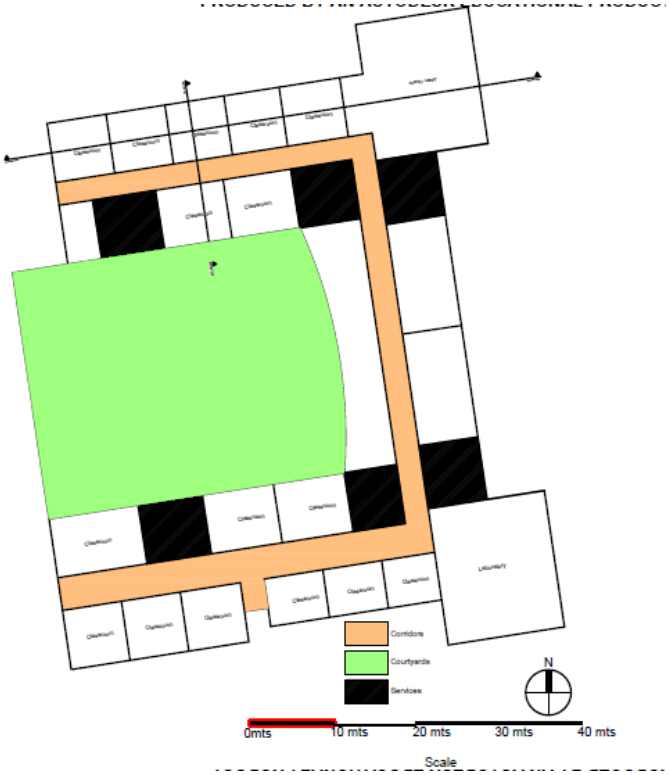


Fig. 5: Layout plan of Case III showing the corridor & courtyard. Source: Author

	
Corridor spaces used for interaction and navigation	Corridors used as Interaction space & Small courtyard at the center used for assembly

Fig 4: Case II; Images showing the use of corridors and outdoor spaces for multiple activities. Source: Author

		
Niches created in the corridor used for interaction	Corridors a for interaction and for navigation	Courtyard small in size used only for assembly

Fig 4: Case III; Images showing the use of corridors and outdoor spaces for multiple activities. Source: Author

3. DAYLIGHT AND THERMAL MEASUREMENTS

Table -1: Daylight levels and thermal comfort for Case I. Source: Author

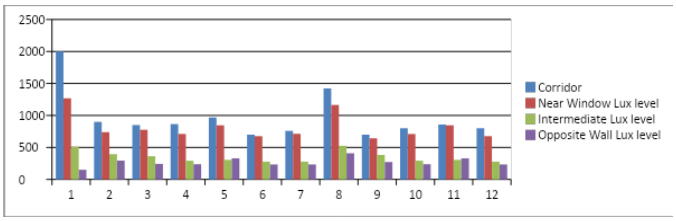


Table -2: Thermal comfort table with PMV values for Case I. Source: Author

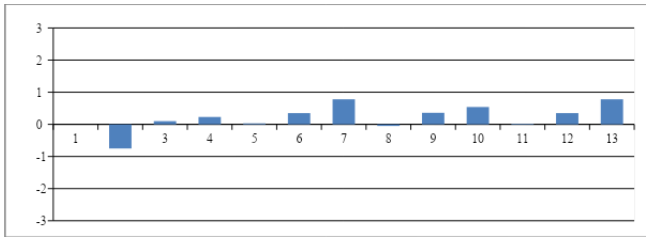


Table -3: Thermal comfort table with PPD values for Case I. Source: Author

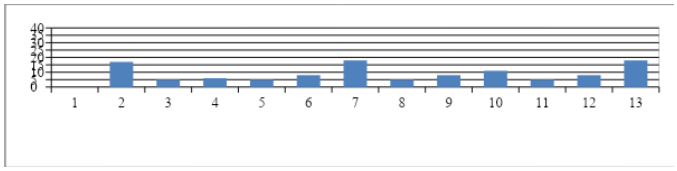


Table -4: Daylight levels and thermal comfort for Case II. Source: Author

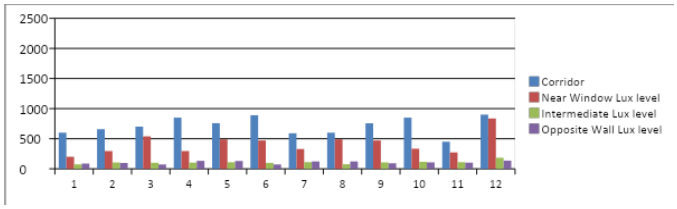


Table -5: Thermal comfort table with PMV values for Case II. Source: Author

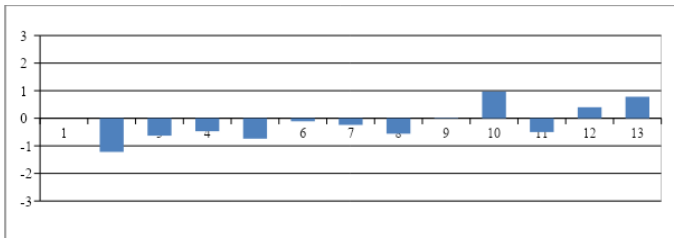


Table -6: Thermal comfort table with PPD values for Case II. Source: Author

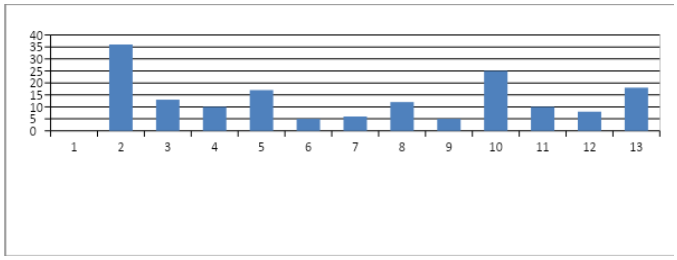


Table -7: Daylight levels and thermal comfort for Case III. Source: Author

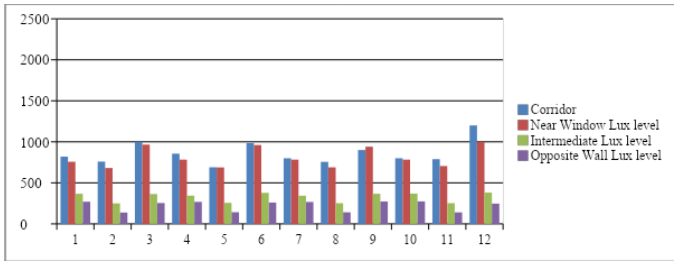


Table -8: Thermal comfort table with PMV values for Case III. Source: Author

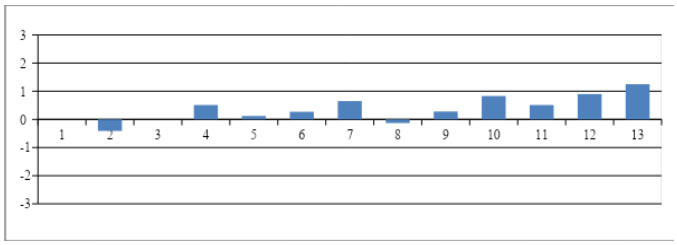
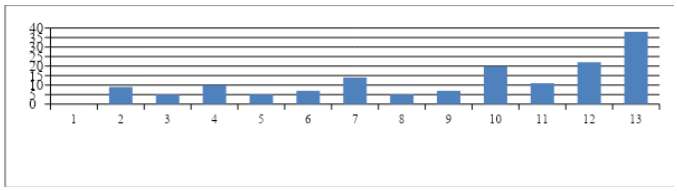


Table -9: Thermal comfort table with PPD values for Case III. Source: Author



3.1 Findings from quantitative data

Table 1. shows the daylight levels in the corridor spaces when compared to the enclosed spaces. It shows a higher lux values making it brighter than the classrooms

Table 2 shows a thermal comfort (PMV) ranging between -.7 to +.7 interpreting a sensation of slightly warm to slightly cold as per ASHRAE thermal comfort scale.

Table 3 shows a PPD of maximum upto 18% where 5% PPD is the lowest percentage of dissatisfied practically achievable since providing an optimal thermal environment for every single person is not possible.

Table 4 shows the daylight levels in the corridor spaces when compared to the enclosed spaces. It shows a higher lux values making it brighter than the classrooms

Table 5 shows a thermal comfort (PMV) ranging between -1.2 to +1 interpreting a sensation of slightly warm to slightly cold as per ASHRAE thermal comfort scale.

Table 6 shows a PPD of maximum upto 35% where 5% PPD is the lowest percentage of dissatisfied practically

achievable since providing an optimal thermal environment for every single person is not possible

Table 7 shows the daylight levels in the corridor spaces when compared to the enclosed spaces. It shows a higher lux values making it brighter than the classrooms

Table 8 shows a thermal comfort (PMV) ranging between -.4 to +1.2 interpreting a sensation of slightly warm to slightly cold as per ASHRAE thermal comfort scale.

Table 9 shows a PPD of maximum upto 30% where 5% PPD is the lowest percentage of dissatisfied practically achievable since providing an optimal thermal environment for every single person is not possible

3.2 Inferences from the graphs:

The daylight graphs for all three schools show that the lux values in the corridor are much higher than the classroom.

The thermal comfort (PMV) graphs show that the sensation level ranges between slightly cool and slightly warm to experience neutral condition most of the time

The PPD scale shows that a maximum of not more than 20% are dissatisfied wherein PPD (Predicted Percentage Dissatisfied) describes the percentage of occupants that are dissatisfied with the given thermal conditions. 5% PPD is the lowest percentage of dissatisfied practically achievable since providing an optimal thermal environment for every single person is not possible. Source: https://www.educate-sustainability.eu/

4. Questionnaire Survey:

The questionnaire survey included 2 parts

Part 1: This included the generic information about the name, age & gender

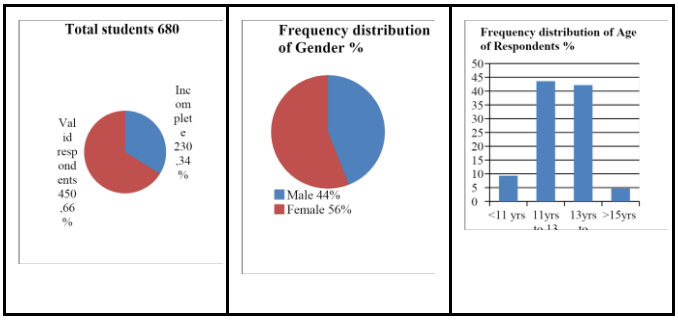
Part 2: This included multiple choice questions for respondents which followed a nominal scale about use of spaces.

Q2 to Q5 & Q9 related to spending time and use of spaces

Q6, & Q7 About activity done in these spaces

Q8, Q10 & Q11 on the quality of spaces.

Table -10: Graph showing generic information.. Source: Author



5. ANALYSIS

A statistical analysis of the questionnaire survey was conducted to have cross tabulation counts with two variables and a chi square test for the same was used for evaluation.

5.1 Cross tabulation counts in Questionnaire survey and Chi square test

Table -11: Cross tabulation count Graph showing climate of courtyard in summer & use of space in summer

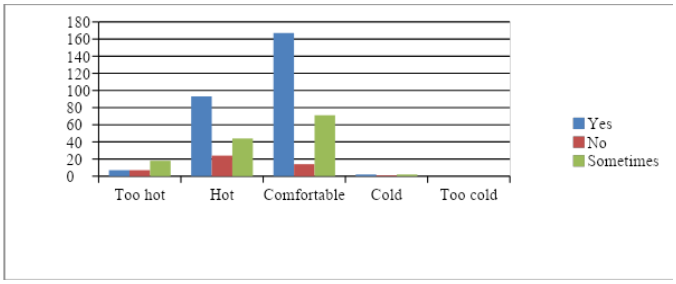


Table -12:. cross tabulation count for Climate in courtyard in summer and use of space in summer

		use of space in summer			Total
		yes	no	some times	
climate of courtyard in summer	too hot	7	7	18	32
	hot	93	24	44	161
	comfortable	167	14	71	252
	cold	2	1	2	5
Total		269	46	135	450

Table -13: Chi-Square Tests results 4 cells (33.3%) have expected count less than 5. The minimum expected count is .51.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	31.626a	6	.000
Likelihood Ratio	32.070	6	.000
Linear-by-Linear Association	9.810	1	.002
N of Valid Cases	450		

5.1.1 Interpretation

Since at df= 6 P value (0.000) is less than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to not accept the null hypothesis

Null hypothesis: Climate and use of space in summer are independent of each other.

Alternative hypothesis: Use of space in summer depends on climatic conditions.

Table -14: Graph showing climate of courtyard in winter & use of space in winter Cross tabulation count

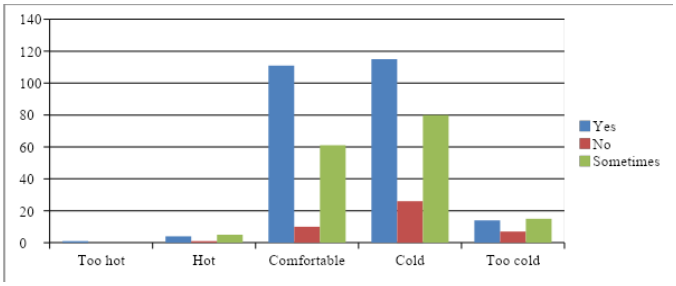


Table -15: Climate of courtyard in winter * use of space in winter Cross tabulation coun

		use of space in winter			Total
		yes	no	some times	
climate of courtyard in winter	too hot	1	0	0	1
	hot	4	1	5	10
	comfortable	111	10	61	182
	cold	115	26	80	221
	too cold	14	7	15	36
Total		245	44	161	450

Table -16:. Chi-Square Tests results 6 cells (40.0%) have expected count less than 5. The minimum expected count is .10.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.421[a]	8	.098
Likelihood Ratio	13.710	8	.090
Linear-by-Linear Association	2.364	1	.124
N of Valid Cases	450		

5.1.2 Interpretation

Since at df= 8 P value (0.098) is more than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to accept the null hypothesis

Null hypothesis: Climate and use of space in winter are dependent on each other.

Table -17 Graph showing age & spent time in corridor Cross tabulation count

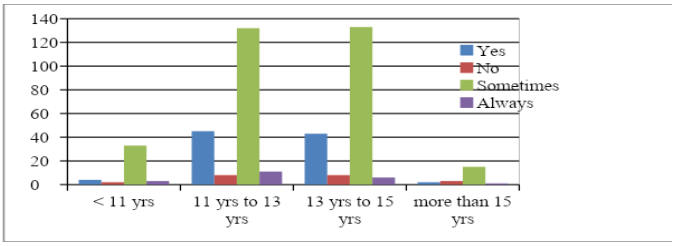


Table -18 Graph showing age & spent time in corridor Cross tabulation count

	spent time in courtyars				Total
	yes	No	some times	always	
less than 11 years	2	15	24	1	42
11-13	19	93	80	4	196
13-15	26	78	83	3	190
more than 15	2	10	8	1	21
5.00	0	0	1	0	1
Total	49	196	196	9	450

Table -19 Chi-Square Tests results 10 cells (50.0%) have expected count less than 5. The minimum expected count is .02.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.292[a]	12	.678
Likelihood Ratio	9.618	12	.649
Linear-by-Linear Association	1.370	1	.242
N of Valid Cases	450		

5.1.3 Interpretation

Since at df= 12 P value (0.678) is more than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to accept the null hypothesis

Null hypothesis: Age and time spent in corridor are dependent of each other, stating that Students studying in higher standard spent more time when compared to younger students in corridors and courtyards

Table -20: Graph showing gender & spent time in corridor Cross tabulation count

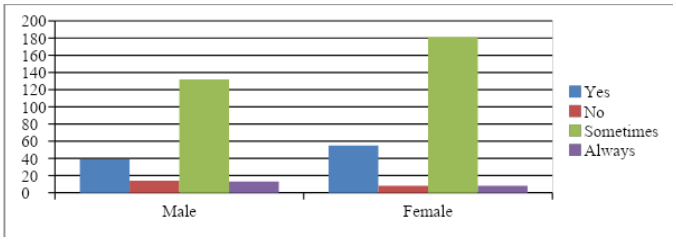


Table -21: gender & spent time in corridor Cross tabulation count

		spent time in corridor				Total
		yes	no	some time	always	
sex	male	39	14	132	13	198
	female	55	8	181	8	252
Total		94	22	313	21	450

Table -22: Chi-Square Tests results 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.24.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.840[a]	3	.077
Likelihood Ratio	6.803	3	.078
Linear-by-Linear Association	.206	1	.650
N of Valid Cases	450		

5.1.4 Interpretation

Since at df= 3 P value (0.077) is more than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to accept the null hypothesis

Null hypothesis: Gender and spending time in the corridor are independent of each other.

Table -23: Graph showing Age & spent time in Courtyards Cross tabulation count

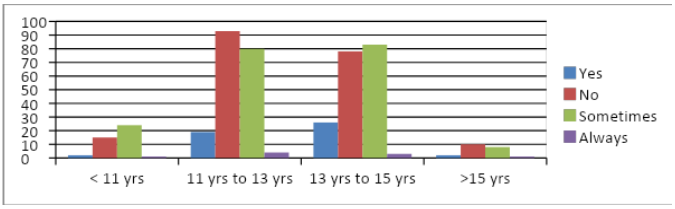


Table -24: Age & spent time in Courtyards Cross tabulation count

		spent time in courtyars				Total
		yes	No	some times	always	
age	less than 11 years	2	15	24	1	42
	11-13	19	93	80	4	196
	13-15	26	78	83	3	190
	more than 15	2	10	8	1	21
	5.00	0	0	1	0	1
Total		49	196	196	9	450

Table -25: Chi-Square Tests results 10 cells (50.0%) have expected count less than 5. The minimum expected count is .02.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.292[a]	12	.678
Likelihood Ratio	9.618	12	.649
Linear-by-Linear Association	1.370	1	.242
N of Valid Cases	450		

5.1.5. Interpretation

Since at df= 12 P value (0.678) is more than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to accept the null hypothesis

Null hypothesis: Age and spending time in courtyards are dependent on each other, stating that Students studying in higher standard spent more time when compared to younger students in corridors and courtyards

Table -26: Graph showing Gender & spent time in Courtyards Cross tabulation count

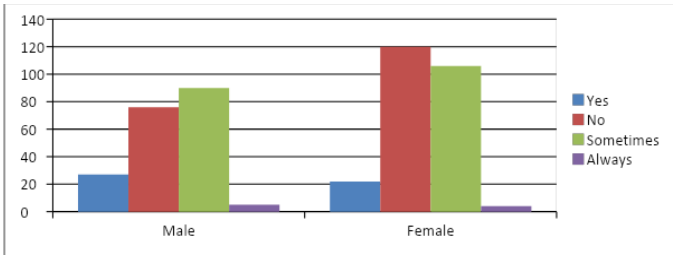


Table -27: Gender & spent time in Courtyards Cross tabulation count

		spent time in courtyards				Total
		yes	no	some times	always	
sex	male	27	76	90	5	198
	female	22	120	106	4	252
Total		49	196	196	9	450

Table -28: Chi-Square Tests results. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 3.96.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.403[a]	3	.145
Likelihood Ratio	5.397	3	.145
Linear-by-Linear Association	.003	1	.957
N of Valid Cases	450		

5.1.6 Interpretation

Since at df= 3 P value (0.145) is more than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to accept the null hypothesis

Null hypothesis: gender and spending time in courtyards are independent of each other.

Table -29: Graph showing spent time in Corridor and use in monsoon Cross tabulation count

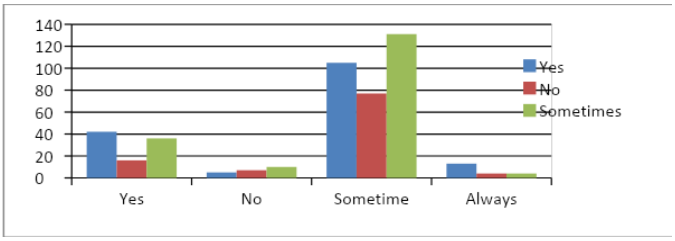


Table -30: Spent time in Corridor and use in monsoon Cross tabulation count

		use of space in monsoon			Total
		Yes	no	sometimes	
spent time in corridor	yes	42	16	36	94
	no	5	7	10	22
	some time	105	77	131	313
	always	13	4	4	21
Total		165	104	181	450

Table -31: Chi-Square Tests results 21 cells (8.3%) have expected count less than 5. The minimum expected count is 4.85.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.756[a]	6	.047
Likelihood Ratio	12.871	6	.045
Linear-by-Linear Association	.085	1	.770
N of Valid Cases	450		

5.1.7 Interpretation

Since at df= 6 P value (0.047) is less than level of significance 0.05 / alpha value (0.05) at 5% level of significance there is sufficient grounds to reject the null hypothesis

Null hypothesis: Spending time in the corridor and use of space in monsoon is independent of each other.

Alternative hypothesis: Students use the corridors in monsoon depending on the type of corridors and restrictions on use and how well they are protected from rain

6. INFERENCES

Table 32. Chi square statistics and inferences

S. No.	Parameter	Chi Square Statistics			Statistical Inferences
		Chi Square value	df	P value	
1	Climate and use of space in summer	31.626	6	0.000	Students use spaces as per their convenience and their activity preferences
2	Climate and use of space in winter	13.421	8	0.098	
3	Age and time spending in corridor	30.762	12	.002	Younger children use these spaces lesser than the elder one since restrictions from the school authority.
4	Sex and time spending in corridor	6.840	3	.077	No relation is seen between the gender and spending time in corridor, it's a personal choice.
5	Age and time spending in courtyard	9.292	12	.678	Younger children use these spaces lesser than the elder one since restrictions from the school authority.
6	Sex and time spending in courtyard	5.403	3	.145	No relation is seen between the gender and spending time in corridor, it's a personal choice.
Red values significant - reject null in favour of alternative					

7. CONCLUSIONS

To conclude the research shows certain findings like use of corridors are dependent on a personal choice depending on the activity, time and the maintenance of the spaces. As there are restrictions on use of spaces depending on age hence the corridors and courtyards are used more by the older children. There is no evidence of gender priority in use of the spaces but generally used as the students wish to use it for their personal choice.

8. DISCUSSION

The thermal measurements and questionnaire survey lead to certain findings which state the behavior of children to semi open areas of the school environment due to the comfort levels and light prevailing in the corridors and courtyards. The conclusion to this research states certain findings from the survey conducted on field and evaluating the same for different conditions as well. Thermal comfort show that that the corridors space lie around neutral conditions & Daylight levels in corridor and courtyard are more than classrooms, hence the students would prefer to spend time and have access to outdoor environment but due to restrictions on use of spaces only during breaks and to different age groups the use depends on age but not the gender. Students studying in higher standard spent more time when compared to younger students. Use of space depends on the climatic condition and depends on what climate is prevailing. For summers it is for fresh air and during winter having access to sunlight and during monsoons it is used only if it is protected from rains and if not dirty. Age and spending time in the corridor/courtyard are independent of each other. The activity mainly happening in the corridors and courtyards are interaction, navigation, and access to the outdoor environment.

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Seema Thippeswamy is Associate Professor at BMS College of Architecture, Bengaluru. She has her bachelor's in architecture and master's in environmental architecture actively engaged as an academician.