

PAPER • OPEN ACCESS

The Impact of Climatic Elements on Formal Optimization for Educational Space (*Evaluation of the reality of local school buildings in Baghdad*)

To cite this article: Maysaa Mofteq and Abdulla Abdulrehman 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **518** 022027

View the [article online](#) for updates and enhancements.

The Impact of Climatic Elements on Formal Optimization for Educational Space (*Evaluation of the reality of local school buildings in Baghdad*)

Maysaa Mofteq¹ and Abdulla Abdulrehman¹

¹Assist Lecturer, Architecture Engineering Department, Mosul University, Mosul, Iraq

Abstract. The Educational Space is an important element of learning and providing an environment that is appropriate to the needs of students helps to increase the level of education, So good design helps improve learning outcomes. For this reason, the design process of the classroom needs appropriate attention taking into account the climatic elements such as Heat, Solar radiation, Wind, Humidity and affecting the student's comfort and the effectiveness of education. The present study defines the research problem as a reformulation of a scientific aspect to study the relations between Climatic Elements and design of school buildings as specific, The aim of the research is to (Evaluate local school models in Baghdad using a program Grasshopper to reach the optimal form for the local environment, the research use a program to introduce climate elements For Baghdad, the research contains three axes: discussing the relation between the climatic elements and design of school buildings and discussing studies about school sustainable design secondly, then Formulation of the theoretical framework, thirdly, its application in practical study, And finally presenting the findings and recommendations..

1. Introduction

The Educational Space is too important element in creating a conducive and stimulating learning environment. It is conducive and suits the needs of the teachers and students, A classroom needs appropriate attention taking into account the climatic elements, Therefore, this research discusses the relationship between climate elements and design of school buildings and it aims to Evaluate local school models to reach the optimal form for the local environment, that would interact and influence the teaching and learning comfort level, which in turn would affect learning.

2. School Buildings:

The school can offer an opportunity to increase learning experience and an educational tool, not just a place full of students, through good design related to the environment and nature..[1]The results of many research studies of the educational environment have shown clear and distinct signs of the importance of providing appropriate conditions for the development of students' performance and academic achievements [2] At the end of the 1990s there was a major shift in the architectural thinking of the adoption of green schools [3] The choice of the formal pattern of school buildings is determined by factors such as determinants of the school, educational level, number of students, educational philosophy of the school, etc., such as site-specific factors and climatic conditions[4]



3. Sustainable schools:

Sustainable architecture also focuses on the role of buildings in protecting the environment from the increasing dangers of global warming, carbon emissions and ozone depletion and the Sustainable green building is a high performance building which is designed so that it has fewer impacts on the environment and human health, consume less water and energy and coexist in harmony with the environment [5], A large number of empirical studies have been conducted on the impact of Climatic Elements on school occupants ,These Elements include thermal factors, lighting quality, natural ventilation, air quality. It has been proven that keeping these elements at an adequate level has a direct positive effect on children's concentration, mood, wellbeing and attainment [6]

3.1 Previous literature:

This Paragraph will review a set of previous literature that dealt with the formal patterns of school buildings and their relation to the climatic environment to conclude the theoretical framework for research:

3.1.1. *Graca et al.,(2007)*: The study discussed the importance of including the initial stages in the process of classroom design to achieve a good climatic environment through elements such as heat, light and sound. The study adopted the analysis of 39 schools in Brazil.[7]

3.1.2. *Dimoudi & Kostarela,(2009)*:

The study pointed to the importance of the environment to be thermally appropriate in the classrooms of the local schools in Greece as it will contribute to prevent pollution of the environment and contribute economically to reduce energy consumption. The study considered that the good classrooms are the internal environment is good and appropriate [8].

3.1.3. *Puteh et al , (2015)*:

The study dealt with the relationship between the design elements of the classrooms in terms of spaces, furniture, ventilation, lighting and the level of comfort that can be provided through 916 students in secondary schools studied in Malaga.[9]

3.1.4. *Haverinen U & Richard j ,(2015)*: The study found that adequate classroom ventilation, lighting and thermal comfort contributed to improving the educational performance of students and included 70 schools in the United States.[10]

All studies have confirmed the importance of the relationship between elements of climate (temperature, humidity, ventilation, wind) and the design of school buildings and through what can be achieved when the interaction of these elements in the design and shown in Figure 1

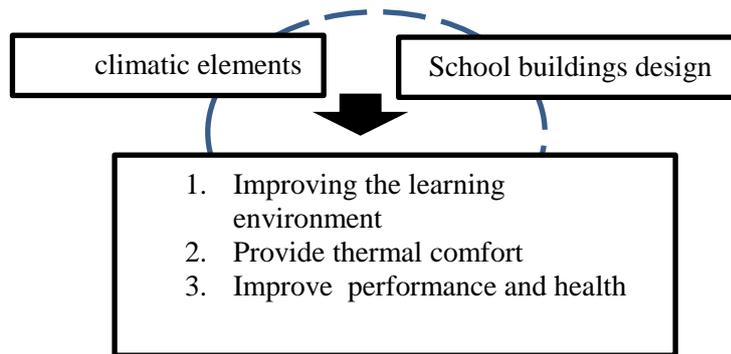


Figure 1. The relationship between climatic elements and School buildings design (researchers).

4. Internal Environmental in School Classes:

Describes a book (Sustainable Schools) in Over the past decade, school buildings in the United States, Britain and a number of countries around the world have been imprisoned. Children and their teachers spend most of their day in poor school buildings in ventilation systems, lighting, visual and audiovisual environments, thermal comfort, outdoor space and maintenance systems, For pupils and teachers working in the school.

[11] Classes are considered to be the most important school spaces in which good environmental considerations must be achieved and should be taken into account in the early design stages, depending on the location and budget conditions and the determinants of their effectiveness and degree of impact. [12] The research will present the climatic elements affecting the design of the school buildings mentioned in previous studies:

4.1. Thermal comfort:

The American Association of Air Conditioning and Refrigeration (ASHRAE) has known thermal comfort as a state of mind in which a person expresses his satisfaction with the thermal environment [13] Achieving a suitable thermal environment within the educational classes is one of the most important factors in achieving good performance for students, because they have a high occupancy rate and increase the thermal gain rate, either from the outside conditions of the sun, or internal gain, such as heat emitted from the metabolism or lighting and devices[12]

4.2. ventilation :

Ventilation of occupied spaces in buildings has primary purposes is to provide an acceptable indoor air quality (IAQ), which essentially is based on the supply of fresh air and the removal or dilution of indoor pollution concentration[14] And most often open windows or mechanical means or both, as a system[12]

4.3. Lighting:

Natural lighting is an important and fundamental criterion in the design of school buildings because it connects the building and its occupants of the students with the natural environment and preferably the main source of lighting within the classrooms of what can be an important factor in achieving a good internal environment[15]. One of the most important variables that affect students' comfort is the level of illumination and their homogeneity on all interior surfaces of space [16].

5. Formal patterns of local school buildings:

We can divide the formal patterns of school buildings into:

5.1. Courtyard Type :

The style of the courtyard: From the simple form, it began to turn into a complex form of several courtyard, to accommodate the absorption of large school buildings[4] show Fig 2.

5.2. Linear Type:

The idea is linear linear axis, and the center of the central assembly with the entrance of the building [17]Fig 3.



Figure 2. Courtyard Type (Source: Iraqi Ministry of Education)

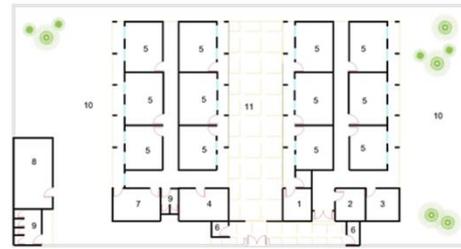


Figure 3. Linear Type (Source: Iraqi Ministry of Education)

6. Practical study

The paper was selected 6 models (Table 1) for the classrooms which represent the local models of the school buildings in Baghdad . The models were introduced for testing in the Grasshopper program by means of two sockets (Ladybug + Honeybee) through two algorithms Fig 4.:

First: Calculate thermal comfort calculation to give results on heat and wind speed

Second: an algorithm to calculate the intensity of natural light entering the classroom space

The following entries are installed into the two algorithms:

- 1- The environmental model of the city of Baghdad, which includes the angles of solarization, latitude and longitude, direction of the wind and its speed during the year and temperatures during the Sunnahs
1. -Directing the openings towards the south exclusively as the best interface locally in terms of the amount of light received
2. Timing: Depending on the academic year represented by the semester from 1 October to 1 June.

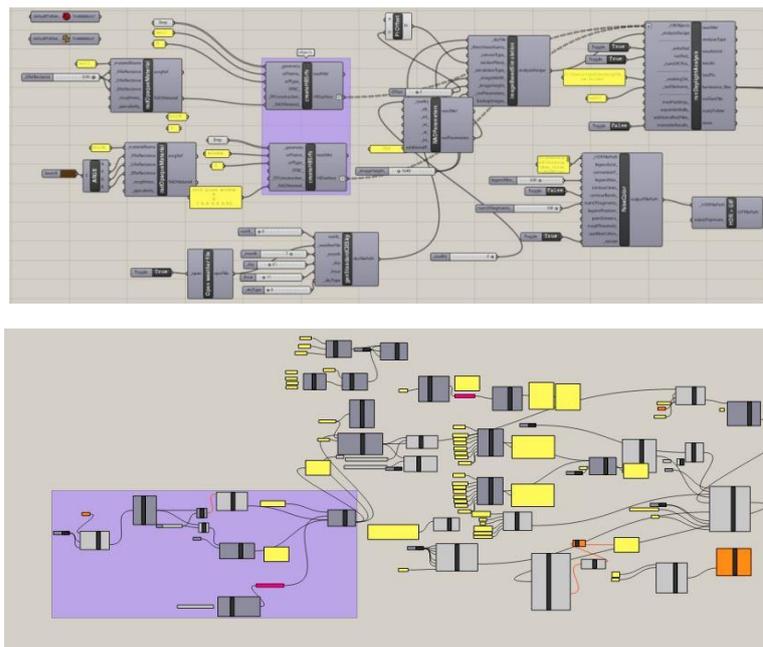
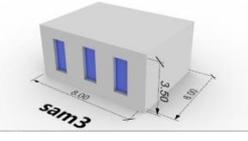
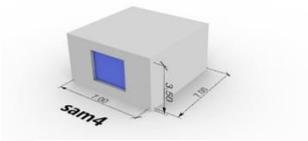
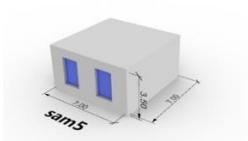
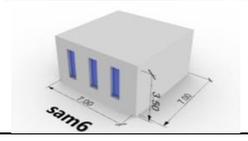


Figure 4. Algorithm Analysis models by program Grasshopper (Ladybug + Honeybee)

The paper bases on the evaluation of the results on the standards issued by ASHRAE and in the final version of 2017 for the thermal comfort of the school buildings, which considered the achievement of the comfortable thermal environment of the human being includes a range of variables such as temperature, humidity, wind and thermal radiation[18] as well as insulation in clothes and activity and in a study prepared on the appropriate environment For school buildings, which showed that the temperature should be maintained between 68 to 78 degrees and 30% to 60% relative humidity,[19] The European norm EN 12464-1 gives requirements for the illuminances in schools which to Reading on blackboard 500 lux and to Paying attention to the teacher its need 300 lux [20]

Table 1. Sample of Classes selected for practical study

name	figure	Interior dimensions of space(M)	Number of windows	dimensions of windows(M)
Sam1		(8*6*3.5)	1	2.4*4
Sam2		(8*6*3.5)	2	2.4*2
Sam3		(8*6*3.5)	3	2.4*1
Sam4		(7*7*3.5)	1	2.4*3
Sam5		(7*7*3.5)	2	2.4*1.5
Sam6		(7*7*3.5)	3	2.4*0.75

7. Application results for practical study:

The research was based on the introduction of the main variables including temperature, relative humidity, solar radiation, angle of fall, date of December 12 as the shortest elevation angle of the sun and the hour is 12 noon, for the rest of the year the sun is more radiant. Windows, which is the optimal guidance, while the openings were different in type, shape and dimensions, including Table 1. The results of the application were as follows: Results related to thermal comfort show in Table 2 , and Model of Quantity for Luminance sample show in Table 3.

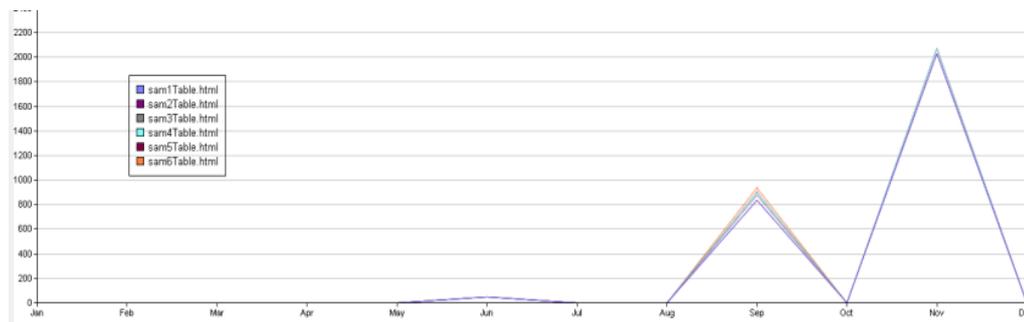
Table 2. Percent (%) of comfortable thermal for sample selected (in Winter)

Name of sample	Interior natural Lighting	Space Heating	Space Cooling
Sam1	23.77%	9.77%	63.1%
Sam2	23.76%	9.78%	63%
Sam3	23.86%	10.31%	62.45%
Sam4	23.87%	10.37%	62.38%
Sam5	23.87%	10.39%	62.36%
Sam6	23.93%	10.8%	61.88%

8. Discussion of results:

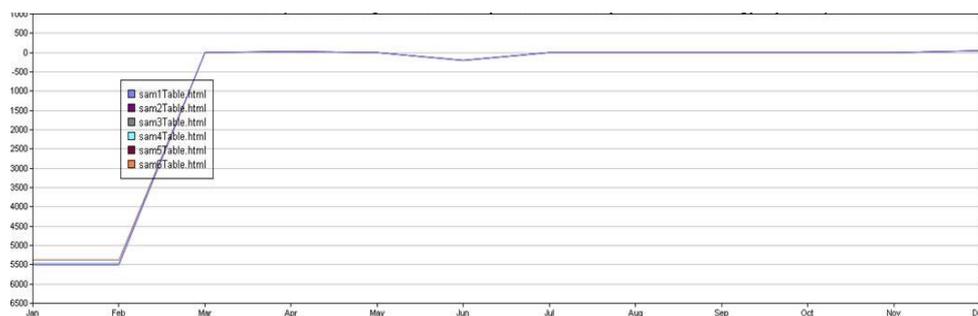
8.1. Results of system Ventilation :

The results showed that (Sam6) obtained the best amount of ventilation within the September month at a rate of ventilation of (900 M³ /sec) because the area of the section (the space of the hole) is inversely proportional to speed, while (Sam4) best amount of ventilation within the November month at the rate of (2100 M³ /sec), the wind in this period of the year is the largest activity according to the adopted climate model. Figure 5.

**Figure 5.** Results of system Ventilation

8.2. Results of sensible of Heat gains component:

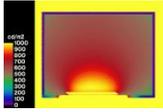
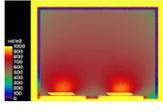
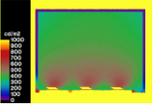
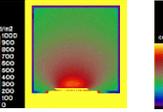
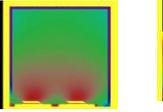
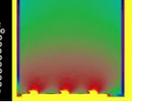
The results showed that the internal space in (Sam1) the largest amount of heat at the rate of (-5500 KW/h) in winter and obtains the largest amount of heat at the rate of (250 KW/h) in summer because this model has the largest area of openings (compared to other models) Figure 6.

**Figure 6.** Results of Heat gains component

8.3. Results of Quantity for Luminance:

The results showed that (Sam4) achieved the best lighting based on their studies, which is a result of the approach of optimizing the vision of the blackboard and drawing attention towards the teacher in the classroom space, then (sap 3 and sam 6) in second level (350 Luminance) Table 3.

Table 3. Model of Quantity for Luminance sample

Name of sample	Sam1	Sam2	Sam3	Sam4	Sam5	Sam6
Model						
Ratio of Window Average of Luminance in class(cd/m^2)	34%	34%	26%	29%	29%	22%
	800	700	350	400	250	350

9. Conclusions

Class spaces represented the most important educational spaces in the schools buildings, which need to employ climatic factors in their design to reach the main purpose of their design to reach buildings that achieve a good and interactive learning environment with students and in harmony with the climate of Iraq and its cities special Baghdad. The level of achievement of this interaction between the design of the classroom and elements of climate for the local Sample of school buildings, where the results showed that the (Sam6) best Sample in achieving this purpose through the best thermal comfort in accordance with(Table 2) (where the best thermal gain 10.8% and less loss 61.88%), and have the best rate suitable for reading and attention to the teacher $350 \text{ cd}/\text{m}^2$, This is due to the variation in the number of openings and the size of the openings relative to the surface area of the row wall containing the openings, which represented 22% of the surface area.

References

- [1] Zhanag J and Zheng Y 2009 An International of Building Green School *journal of sustainable development* **2** 200.
- [2] Sigurdardottir A and Hjartarson T 2011 School Buildings for the 21st Century Some Features of New School Buildings in Iceland *c e p s Journal* **1** 25.
- [3] Yudelson J P 2007 Green Building A to B Understanding the Language of Green Building (Canada) p119.
- [4] Perkins B 2001 Building Type Basic for Elementary and Secondary School (*john Wiley & Son:New York*) p64-P65.
- [5] Yudelson J P 2008 The green building revolution (Island Pr)
- [6] Woolner P Hall E Higgins S McCaughey C & Wall K 2007 What we know about the impact of environments on learning and the implications for Building Schools for the Future (Oxford Review of Education) p47-70
- [7] Graca et al. 2007 An evaluation method for school building design at the preliminary phase with optimisation of aspects of environmental comfort for the school system of the State São Paulo in Brazil

- [8] Dimoudi & Kostarela 2009 Energy monitoring and conservation potential in school buildings in the C' climatic zone of Greece.
- [9] Puteh et al. 2015 The Classroom Physical Environment and Its Relation to Teaching and Learning Comfort Level .
- [10] Haverinen U & Richard j 2015 Effects of Classroom Ventilation Rate and Temperature on Students' Test Scores.
- [11] Ford A 2007 Design the sustainable school (Australia) p12.
- [12] Scottish Executive 2007 School Design: Optimising The Internal Environment- Building Our Future: Scotland's School Estate (Crown, ISBN:978-0-7559-5260-1, Edinburgh) p25-p37-p19.
- [13] ASHRAE 2009 *ASHRAE Handbook: Fundamentals* (Inch-Pound Edition, Atlanta GA, American Society of Heating Refrigerating Air Conditioning Engineering, Inc).
- [14] Kleiven T 2003 Natural Ventilation in Buildings Architectural concepts, consequences and possibilities (*Thesis submitted* in partial fulfilment of the requirements for the degree of Doktor Ingenior ; Norwegian University of Science and Technology).
- [15] Maren B, Lighter Schools Brighter Futures Design Guide , Brett Martin Daylight Systems Ltd, Sandford Close, Aldermans Green Industrial Estate, Coventry, West Midlands CV2 2QU
- [16] Rsoqi D 1987 Planning and Design Basis and its Impact on the Performance of the School Buildings in Iraq (*Master Thesis*, Department of Architecture, College of Engineering, Baghdad University).
- [17] Dudek M, 2007 A DESIGN MANUAL Schools and Kindergartens, (Birkhauser Verlag AG) p21.
- [18] ASHRAE 2017 ANSI/ASHRAE Standard 55
- [19] Pennsylvania Department of Health, Indoor Air Quality Guidelines for Pennsylvania Schools .
- [20] Hordijk T & Groot E, Lighting in schools, Netherlands.