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Optimising Classroom Orientation for Energy Efficiency in Iraq's Kurdistan Region: A Simulation-Based Approach

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Abstract: The orientation of a classroom window (its azimuth) plays an important role in both energy use and indoor temperature. This is particularly relevant for schools in the Kurdistan Region of Iraq, where the climate can vary significantly. To investigate this effect, a simulation-based approach was applied using a parametric model of a typical classroom. The model was rotated in 15° increments, yielding 24 distinct orientation scenarios for analysis and comparison. This study is among the first simulation-based investigations in the Kurdistan Region of Iraq to provide orientation-specific design guidance for school classrooms. The study examined energy demand for heating, cooling, and lighting, as well as carbon dioxide emissions and comfort hours in a classroom over a full academic year.

Results indicate that classrooms with windows oriented at 165° and 180° yield the most energy-efficient outcomes. Showing up to 8% reduction in total electricity use and CO_2 emissions compared to the worst-performing orientations (30° and 45°). South-facing orientations also maximised daylight availability and reduced lighting loads by around 40%. Conversely, North-East orientations significantly increased both heating and lighting demand. The findings recommend prioritising Southeast-to-Southwest windows in future school design in similar climatic contexts to enhance energy efficiency and indoor environmental quality.

Keywords: *Optimum Orientation; Energy Performance; Classroom Orientation; Thermal Comfort; Environmental Performance Simulation; Energy Efficiency In Educational Buildings; Classroom Thermal Performance; Sustainable School Design.*

1. Introduction

In the context of education, students spend a large portion of their daily physical activity in school buildings. These environments are expected to support high-quality learning while ensuring the well-being, comfort, and safety of their occupants. At the same time, maintaining acceptable indoor conditions requires considerable energy. Due to their long operating hours and high occupancy levels, schools and other educational facilities account for a significant share of this demand.

Globally, the operation of the building sector is a major contributor to energy consumption. According to the International Energy Agency (IEA), more than one-third of the world's energy is consumed by activities such as heating, cooling, lighting, and operating equipment within all types of buildings. These building operations are also linked to approximately 26% of total carbon dioxide emissions worldwide [1].

Similarly, at the regional level, based on the Sustainable Energy Action Plan (SEAP) for Sulaymaniyah Governorate (Sulaimani), a UNDP-supported and European Union-funded project, electricity use and related emissions in school buildings in the Kurdistan Region of Iraq were found to be relatively high. The report indicated that a single typical classroom used approximately 2,295 kWh of electricity every year. Besides, it showed that non-residential buildings, including schools, account for about 8% of total emissions [2].

According to the SEAP, local authorities in Sulaimani are planning to reduce total emissions by 40% by 2030 [2], in line with the UN Sustainable Development Goals (especially SDG 4 and SDG 7) [3]. Yet reaching this target is not only about policies. In reality, it also depends a lot on how buildings are designed and used in practice.

Although several studies have been conducted on school environments in the Kurdistan Region of Iraq, most have focused primarily on spatial quality, usability, learning environments, and daylight performance. To the best of the author's knowledge, no previous study has quantitatively examined how classroom window orientation affects annual heating, cooling, lighting demand, CO_2 emissions, and indoor comfort conditions under the climatic conditions of Sulaimani. Therefore, the present study contributes a context-specific simulation-based assessment that aims to provide practical design guidance for future sustainable school buildings in the region.

2. Literature Review

Many studies worldwide have examined how various design factors influence energy use in school buildings. Orientation of the classes is one of the many variables that affect building efficiency, and it is a common theme in this research. Specifically, the direction of a room determines how much solar heat it gains, which clearly affects its indoor temperatures and energy behaviour. Therefore, this changes the room's heating and cooling requirements depending on the local climate.

For instance, in Shanghai's humid subtropical climate, east-facing classrooms were found to consume 4.8% to 8.3% less energy than west-facing classrooms [4]. Whereas, in China's Hot Summer and Cold Winter region, studies examining the impact of orientation on energy performance suggested that south-facing classrooms were the most energy-efficient [5]. This has been supported by another investigation in the same region, which confirmed that classrooms aligned toward the south used the least energy annually (58.55 kWh/m²). In contrast, west-facing orientations consumed the most (63.01 kWh/m²). The latter paper also suggests that maintaining orientation within ±15° of due south can optimise a building's year-round energy performance [6].

Furthermore, studies in Mediterranean climates present similar findings. A simulation of educational buildings in Greece, conducted across different seasons, suggested that north–south orientations generally outperform east–west layouts [7]. While research in Cyprus indicated an optimal azimuth near 171° [8]. Conversely, an investigation in Gaza, Palestine, found that east- and south-facing schools required more energy than other orientations [9].

In hot and dry climates such as Shiraz, in Iran, orientation adjustments have been shown to reduce energy demand by up to 25% [10]. Besides, in Zahedan, it was found that educational buildings oriented 109° from North consumed the least energy; whereas those oriented at 30° consumed the most [11].

In contexts more comparable to Sulaimani, a multi-objective optimisation study using Tehran's weather data reported potential energy savings of 47.9 kWh/m² when classroom orientation and other related parameters were optimised. The study also noted that orientation has a substantial influence on solar exposure and indoor thermal comfort [12].

Within the Kurdistan Region of Iraq, research on schools has mainly focused on improving spatial design and learning environments. For instance, Tayib and Hassan used surveys and analytical methods to demonstrate that students' physical, cognitive, and social needs are closely associated with learning outcomes [13]. Zewar proposed redesigns for both L-shaped and O-shaped schools to enhance corridor usability [14]. While Swar, Khayat, and Amin identified limitations in spatial diversity when comparing local schools with British counterparts [15]. Additionally, Mustafa, Amin, and Swar examined daylight performance in six schools with varying sizes, forms, and spatial configurations [16].

Despite these contributions, most existing work emphasises spatial organisation, usability, and visual aspects, with limited attention to how design parameters, such as classroom orientation, influence thermal energy performance and lighting demand. Therefore, there remains a lack of quantitative analysis linking orientation to energy usage while maintaining acceptable indoor thermal and visual conditions.

2.1 Research Gap

The energy performance of school buildings in the Kurdistan Region of Iraq has not been widely explored in the existing literature. In particular, limited attention has been given to the role of passive design strategies in improving the thermal behaviour and energy efficiency of educational buildings. More importantly, there is a lack of quantitative studies examining how classroom orientation influences HVAC (heating, ventilation, and air conditioning) and lighting energy demand while maintaining acceptable indoor thermal and visual comfort. Therefore, the development of context-specific and evidence-based design guidelines for energy-efficient schools in the region remains constrained.

2.2 Aims of the Study

In response to this gap, the present study seeks to identify an optimal classroom orientation to reduce energy consumption while maintaining indoor comfort. To achieve this, a simulation-based approach is adopted to examine how variations in azimuth orientation affect thermal performance and lighting energy demand in school buildings located in Sulaimani.

2.3 Scope of the Research

This study examines the influence of classroom orientation on energy performance within the specific climatic and architectural context of Sulaimani. The analysis is carried out using a simulation model of a prototypical classroom, in which key design parameters are controlled to isolate the effect of orientation. The outcomes of this study mainly reflect the specific conditions of Sulaimani. Therefore, caution should be taken when applying the results to other regions with different climates or building practices.

In this work, one prototype classroom was used intentionally to examine the effect of orientation more clearly. All other design parameters were kept unchanged to ensure that the differences in the results came only from the azimuth angle. This helped to show the specific influence of orientation on classroom energy performance.

3. Research Methodology

In this paper, a simulation-based method was applied to assess the energy performance of a typical classroom. The analysis was conducted using DesignBuilder (V6.1.0.006), a widely used tool for building energy studies. This software is based on the EnergyPlus engine to calculate the energy required to maintain comfortable indoor environments. It also provides estimates of the emissions generated by building operations, among many other outcomes [17].

First of all, the above-mentioned 3D model was modelled parametrically based on common local building practices. More specific details about these settings are provided in Sections 3.1 to 3.4, including standard sizes, typical materials, and an HVAC system modified to meet thermal comfort conditions in the classroom. Then, the prototype was analysed at different azimuths to determine the effect of classroom rotation on energy demand and emissions.

In this work, orientation was treated as the primary independent variable, while all other design and operational parameters remained unchanged throughout the simulations. This made it possible to directly evaluate the specific contribution of window direction to classroom energy performance.

3.1 Prototype Model

In school design, architectural standards support rectangular classrooms with a width-to-length ratio of 2:3 or 3:4, favouring long facades to enhance natural daylighting. In addition, to ensure visual and spatial comfort, the standard recommends that the distance from the front teaching wall to the furthest desk should not exceed 9.00 meters. Similarly, the room depth should be limited to 7.20 meters when there is only one wall with windows. Besides, the minimum clear height of the room should be at least 2.70 meters. According to the reference, it is also advised to accommodate 24 to 32 students per class. This provides approximately 1.8-2.00 m² of floor area per student and 5.00–6.00 m³ of air volume per student [18].

Figure 1: The prototype model used in the analysis.

Following these guidelines, a prototype classroom was developed to accommodate 30 students. The archetype model features internal dimensions of 9.00 meters in length, 7.20 meters in width, and 2.70 meters in height, as illustrated in Figure 1. In detail, typical local building materials were applied, with an infiltration rate of 0.7 ac/h, as illustrated in Figure 2. Furthermore, the space's openings are filled with double-glazed windows. The glazing consists of 6 mm clear glass panes separated by a 13 mm air cavity, framed in aluminium with thermal breaks. In the design, these windows are installed along one of the classroom's longer facades.

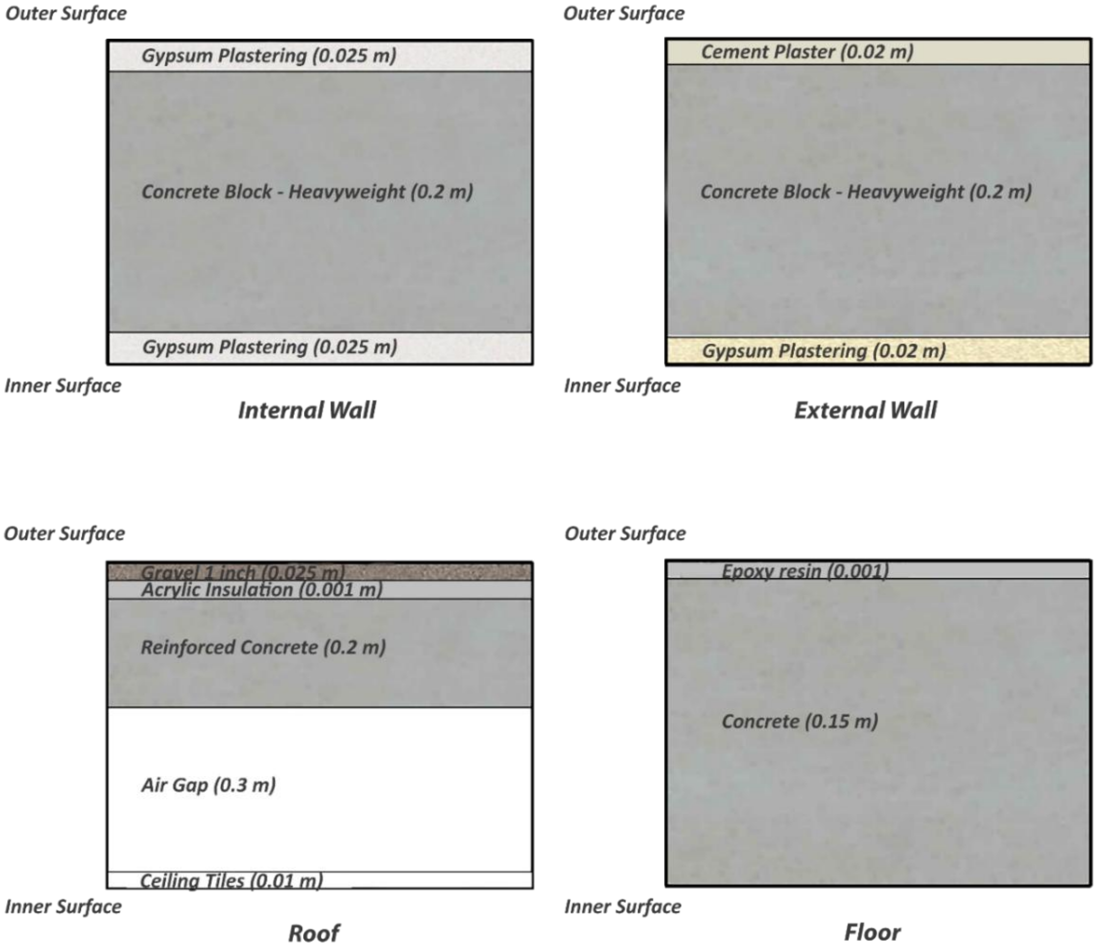


Figure 2: The construction materials used in the prototype classroom model.

3.2 Climate Data

In this study, weather data for Sulaimani were integrated into DesignBuilder to perform a realistic analysis of the prototype model. The dataset was obtained from an EnergyPlus Weather (EPW) file, which represents a typical meteorological year and is based on hourly records from 2009 to 2023 [19].

Sulaimani is located at approximately 35.55° latitude and 45.45° longitude and is classified as a Csa climate. This means that this area usually has hot, dry summers and colder winters with some rainfall [20]. The temperature trends and solar path diagrams for the city, shown in Figure 3, indicate noticeable fluctuations between diurnal and seasonal temperatures. This gives us an idea to interpret seasonal heating and cooling demand trends in Sulaimani.

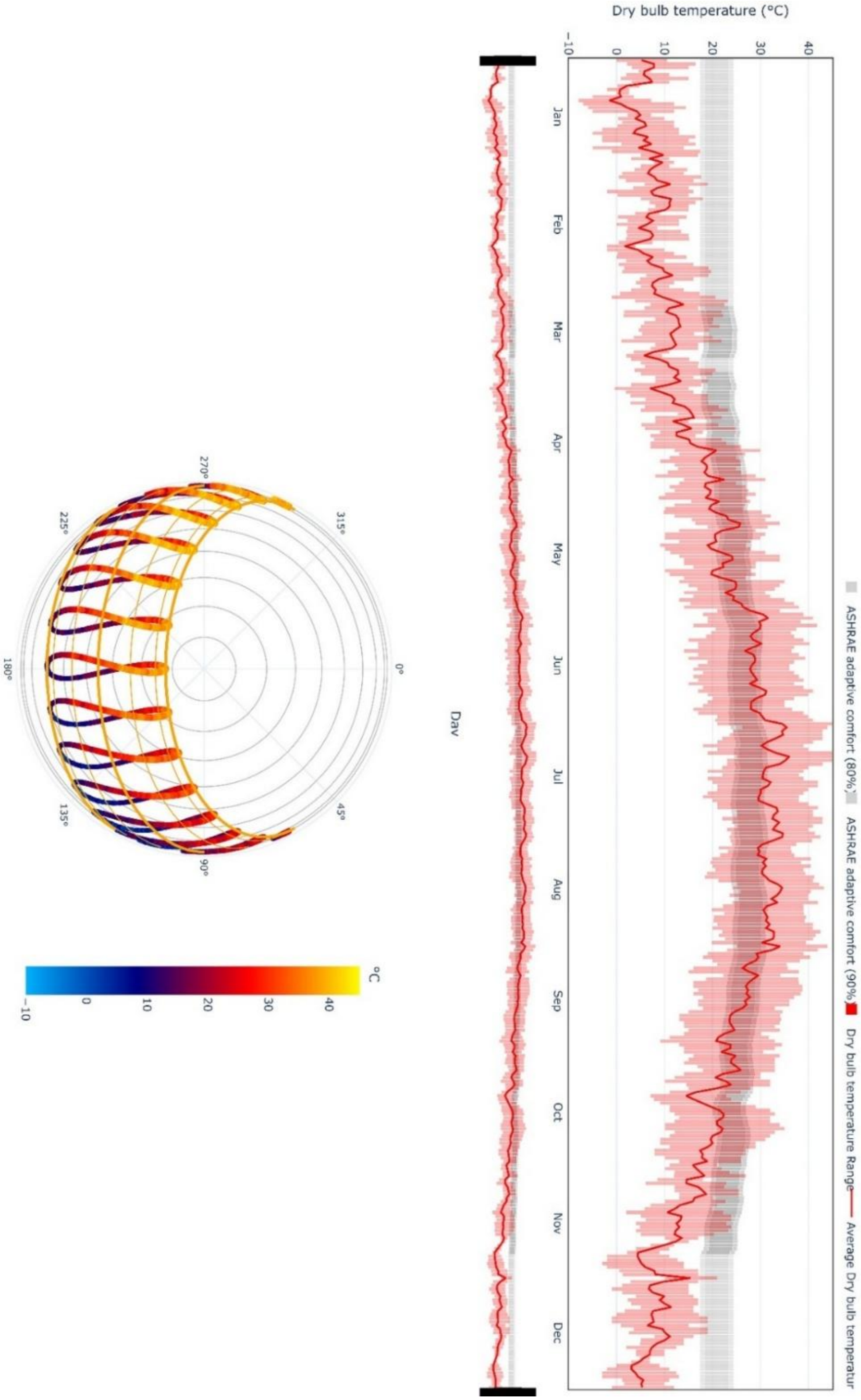


Figure 3: Temperature changes over the year and solar path in Sulaimani, created from EPW climate data using the CBE Clima Tool [21].

3.3 User Comfort

For educational spaces like lecture halls, the Chartered Institution of Building Services Engineers (CIBSE) recommends an indoor operative temperature of 19-21°C in winter (1.4 met, 1.0 clo), and 21-23°C in summer (1.4 met, 0,65 clo). An air supply rate of 10 L/s per person and a 300-500 lux lighting illumination are also advised by the guidebook [22]. These parameters informed the thermal and visual comfort settings used in the simulation.

To ensure thermal comfort, a commonly used HVAC system was implemented in the design. A Variable Refrigerant Flow (VRF) system with fixed operating times (08:00-16:00) was simulated to measure the heating, ventilation, and cooling loads. Additionally, an LED lighting system was set to maintain 300 lux with a maximum glare index of 22.0.

3.4 Operating Hours

In the Kurdistan Region of Iraq, the academic calendar extends from September to July. Schools operate on a full-time basis, and students typically attend classes between 8:00 am and 4:00 pm, with the possibility of two-shift attendance when necessary [23].

For accuracy and to reflect real-world usage, the prototype's operational settings in DesignBuilder were adjusted to align with this schedule before conducting the simulations.

3.5 Analysis

The classroom's performance was simulated 24 times by rotating the prototype in 15° increments. The initial simulation started with the classroom's windows facing 180° (True South) and proceeded clockwise through a full 360° rotation, as shown in Figure 4. The rotation was to determine the correlation between changing the prototype's direction and its annual energy demand, while ensuring year-round thermal comfort in all cases.

The analysis primarily examined heating, cooling, and lighting loads. In addition, the outcomes included the amount of emissions produced and indoor environmental quality, calculated as the annual percentage of comfort hours in the classroom.

Besides, by keeping all other variables (such as space height, windows-to-wall ratio, etc.) fixed, the calculations accurately measured the change in CO_2 emissions and energy usage with each 15° rotation.

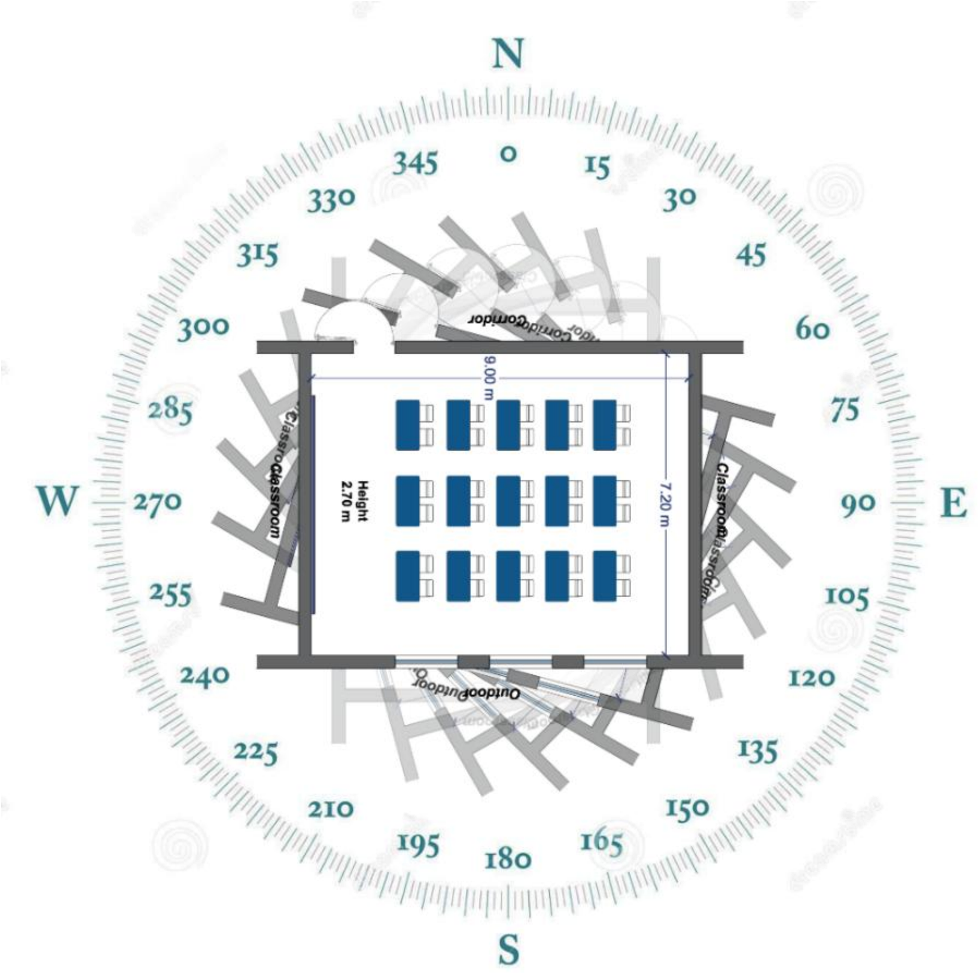


Figure 4 illustrates the analysis process, with the classroom model rotated in 15° increments.

4. Results

4.1 Thermal Comfort

Table 1 presents detailed thermal comfort data and illustrates the distribution of comfort and discomfort hours across classrooms with various window orientations (azimuths). To be precise, in the table, the comfort levels were measured as a percentage of the total 2072 occupied hours in an academic year. Also, comfort temperatures were defined as 19°C to 21°C during the heating season, and 21°C to 23°C during the cooling season. Through all scenarios, the classroom prototype maintained a thermally comfortable indoor environment during occupied hours.

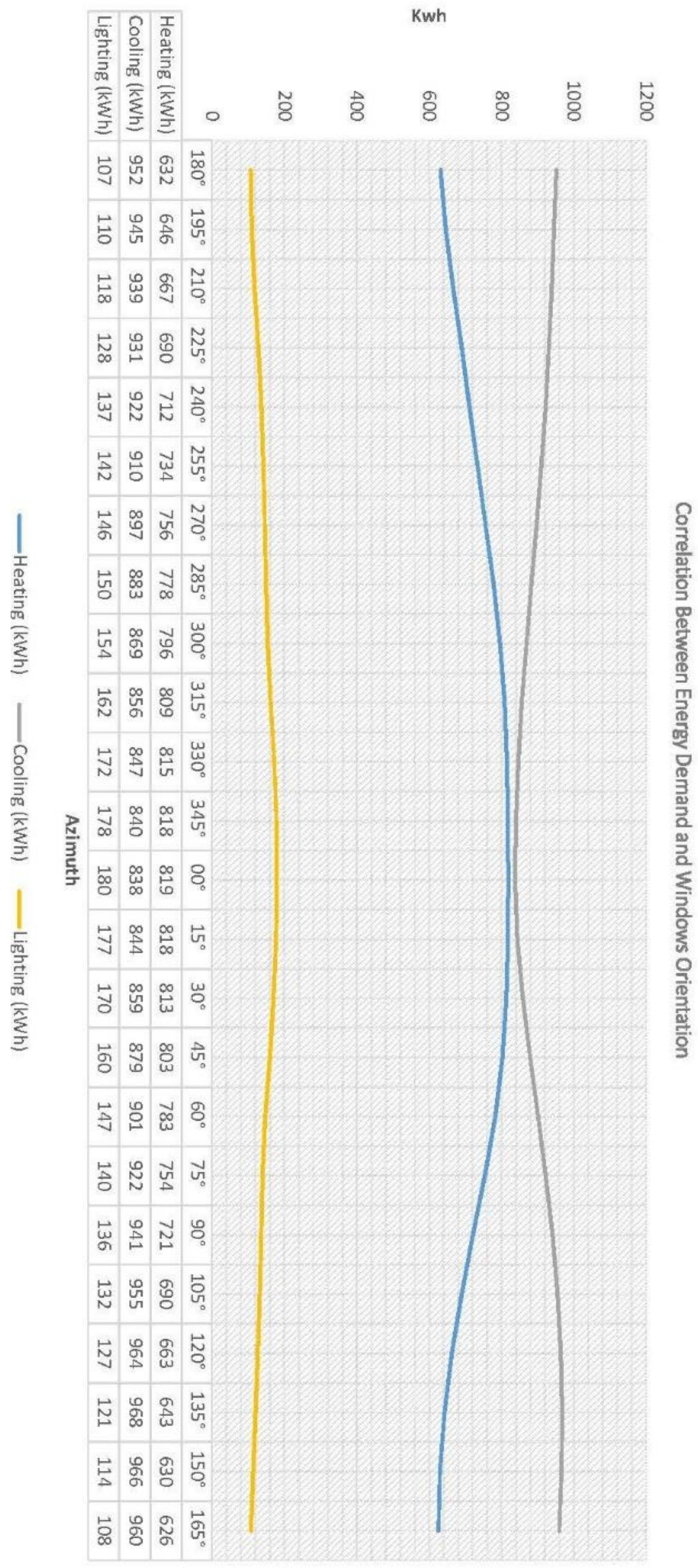
Besides, in all analysed cases, indoor temperatures remained stable, falling within the defined comfort zone of 19°C to 23°C, with the class's temperature never dropping below 19°C or exceeding 29°C, and the percentage of comfort hours in the space ranged between 91% and 94%. Overall, this reflects the model's stable thermal behaviour and supports a consistent comparison of the impact of window orientation on both energy demand and CO_2 emissions.

Table 1: Displays annual air temperature by classroom orientation with corresponding comfort and discomfort hours.

Windows Facing Azimuth (°)	Comfort Hours		Discomfort Hours					
	Between (19°C to 23°C)		Cold Discomfort		Hot Discomfort		Total	
	No. of Comfort Hours (h)	Comfort Ratio (%)	No. of Hours (<19°C)	Minimum Recorded Temp (°C)	No. of Overheating Hours (>23°C)	Maximum Recorded Temp (°C)	Total Discomfort Hours (h)	Total Discomfort (%)
180°	1900.5	92%	0	19°C	171.5	29°C	171.5	8%
195°	1895.5	91%	0	19°C	176.5	29°C	176.5	9%
210°	1892.5	91%	0	20°C	179.5	29°C	179.5	9%
225°	1895	91%	0	19°C	177	29°C	177	9%
240°	1903.5	92%	0	19°C	168.5	29°C	168.5	8%
255°	1914	92%	0	19°C	158	29°C	158	8%
270°	1926.5	93%	0	19°C	145.5	29°C	145.5	7%
285°	1935.5	93%	0	19°C	136.5	29°C	136.5	7%
300°	1939.5	94%	0	19°C	132.5	29°C	132.5	6%
315°	1943.5	94%	0	19°C	128.5	29°C	128.5	6%
330°	1946	94%	0	19°C	126	29°C	126	6%
345°	1947.5	94%	0	19°C	124.5	29°C	124.5	6%
00°	1948.5	94%	0	19°C	123.5	29°C	123.5	6%
15°	1947	94%	0	19°C	125	29°C	125	6%
30°	1946.5	94%	0	19°C	125.5	29°C	125.5	6%
45°	1945	94%	0	19°C	127	29°C	127	6%
60°	1943	94%	0	19°C	129	29°C	129	6%
75°	1941	94%	0	19°C	131	29°C	131	6%
90°	1939	94%	0	19°C	133	29°C	133	6%
105°	1936.5	93%	0	19°C	135.5	29°C	135.5	7%
120°	1935	93%	0	19°C	137	29°C	137	7%
135°	1933.5	93%	0	19°C	138.5	29°C	138.5	7%
150°	1928	93%	0	19°C	144	29°C	144	7%
165°	1913.5	92%	0	19°C	158.5	29°C	158.5	8%
Note: Total occupied hours per academic year = 2072 h. Comfort range was defined as 19–21°C during the heating season and 21–23°C during the cooling season.								

4.2 Heating, Cooling, and Lighting Demands

Figure 5 shows the yearly energy demand (kWh) of the classroom model. The results are presented for different orientations, with the model rotated in 15 ° increments. It starts from 180° (true south) and continues clockwise until 165°. The figure shows three main energy aspects, which are heating, cooling, and lighting loads, for all 24 orientation cases.



	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°	00°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
Heating (kWh)	632	646	667	690	712	734	756	778	796	809	815	818	819	818	813	803	783	754	721	690	663	643	630	626
Cooling (kWh)	952	945	939	931	922	910	897	883	869	856	847	840	838	844	859	879	901	922	941	955	964	968	966	960
Lighting (kWh)	107	110	118	128	137	142	146	150	154	162	172	178	180	177	170	160	147	140	136	132	127	121	114	108

Figure 5 illustrates the relationship between window orientation and energy demand for heating, cooling, and lighting.

4.3 Heating Demand

- The heating load is at its lowest value at azimuths 165° (626 kWh) and then 180° (632 kWh). Whilst it is at the highest demand at 00° (819 kWh), marking a 30.8% increase from the lowest point.
- Heating demand generally increases as the orientation shifts away from True South towards the Northwest (345°). Thereafter, it gradually decreases as it returns toward the Southeast (165°).
- This suggests that classrooms with windows facing Southeast to Southwest (between 135° and 195°) reduce heating energy, likely due to better solar heat gain during cold months.

4.4 Cooling Demand

- The cooling demand reaches its peak at 135° (968 kWh), which is 15.5% higher than the lowest recorded demand at 00° (838 kWh) and 345° (840 kWh), respectively.
- As the window orientation shifts clockwise from 135° to 00°, cooling loads drop. Though it rises again as windows begin to face the Northeast and East.
- This data indicated that Southeast to Southwest oriented windows (105° to 195°) increase solar gain during hot periods, as a result increasing cooling loads.

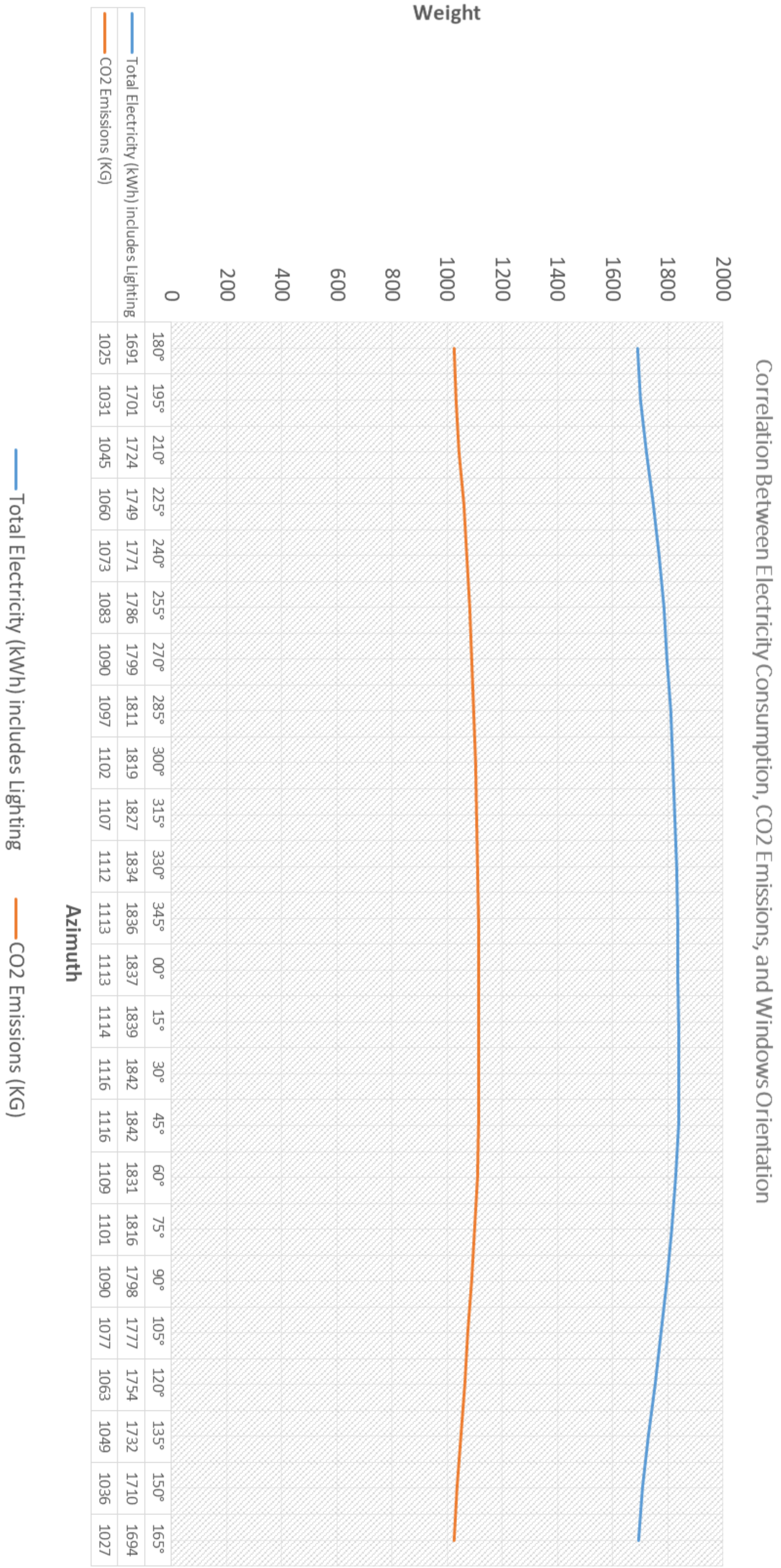
4.5 Lighting Demand

- In terms of lighting, the lowest electricity demand is observed at 180° (107 kWh) and 165° (108 kWh) for the prototype. Whilst the highest is recorded at 00° (180 kWh), 345° (178 kWh), and 15° (177 kWh), respectively.
- This data reflects a 68% increase from the minimum to the maximum electricity usage for lighting.
- It also shows that southern exposure windows receive optimal daylight, which leads to the least reliance on artificial lighting.
- In contrast, classrooms with windows facing North, Northeast, and Northwest suffer from insufficient daylight penetration.

4.6 Total Energy Demand and CO2 Emissions

From the simulations, Figure 6 breaks down the total electricity consumption and CO_2 emissions across the 24 scenarios of the classroom, and it shows that:

- The most energy efficient class configuration is at azimuth 180° (Windows towards True South), where the classroom consumes (1691 kWh), and emits the lowest CO_2 emissions (1025 kg).
- On the other hand, the least efficient orientations are at 30° and 45° (Northeast), which consume the highest electricity (1842 kWh) and emit (1116 kg) CO_2 emissions.
- Both inefficient orientations represent an 8.9% increase in energy usage and greenhouse gas emissions compared to the most efficient case.



	180°	195°	210°	225°	240°	255°	270°	285°	300°	315°	330°	345°	00°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°
Total Electricity (kWh) includes Lighting	1691	1701	1724	1749	1771	1786	1799	1811	1819	1827	1834	1836	1837	1839	1842	1842	1831	1816	1798	1777	1754	1732	1710	1694
CO2 Emissions (KG)	1025	1031	1045	1060	1073	1083	1090	1097	1102	1107	1112	1113	1113	1114	1116	1116	1109	1101	1090	1077	1063	1049	1036	1027

Figure 6: Shows the relation between total energy demand, CO_2 emissions, and the different window orientations in all 24 simulation cases.

The obtained results are generally consistent with findings reported in previous international studies. Similar to research conducted in China [5,6], Greece [7], and Cyprus [8], the present study confirms that south-facing or near-south orientations tend to offer better annual energy performance. The lower heating and lighting demands observed between 165° and 195° support the broader conclusion that orientations close to the true south are more suitable for educational buildings in climates with both cooling and heating requirements.

5. Conclusions

This study provides one of the first orientation-specific energy performance assessments for school classrooms under the climatic conditions of the Kurdistan Region of Iraq. The outcomes of this research can support the design of more sustainable schools and are particularly relevant to regions with climates like Sulaymaniyah, where balancing winter heating and summer cooling is important for building performance. This study concludes that the most energy-efficient window orientation for classrooms is between 165° and 195° (Southeast to Southwest). Overall, the analysis demonstrates that the classrooms oriented optimally within that range perform much better. Consequently, it reduces heating, lighting, and CO_2 emissions and moderates cooling demand.

On the other hand, it is also recommended to avoid window orientations between 30° and 45°. Classes with those window facings result in the highest total energy consumption and CO_2 emissions. These orientations significantly increase both heating and lighting energy demands, making them the least efficient options for classroom design.

6. Limitations and Recommendations for Future Research

This study has several limitations. The simulations did not account for variables such as occupant behaviour, furniture layout, internal heat gains from equipment and occupants, glare from solar radiation, or variations in occupancy patterns. Additionally, no internal or external shading devices were included in the model to isolate the effect of orientation. Variations in window area and window-to-wall ratio (WWR) were also not taken into account. These factors may influence real-world energy performance and should be addressed in future research.

A further limitation of this study is that the analysis was conducted at the scale of a single prototype classroom rather than at the scale of a complete school building. In practice, school buildings contain multiple classrooms, circulation spaces, and supporting facilities that may differ in orientation, internal gains, and exposure conditions. However, the purpose of the present research was to isolate the effect of classroom azimuth on energy performance under controlled conditions. Future studies are recommended to expand the simulation scope to full school-building models to evaluate the combined influence of classroom orientation, building form, shared-envelope conditions, and internal spatial arrangements on total energy performance.

Author’s Contribution

The author is responsible for all roles in this paper (Conceptualisation; methodology; software; validation; formal analysis; investigation; resources; data curation; writing—original draft preparation; writing—review and editing; visualisation; supervision; project administration; and funding acquisition). The author has read and agreed to the published version of the manuscript.

Conflict of Interest

There is no conflict of interest for this paper.

Use of the AI tool declaration

The authors declare that any AI tools used in the preparation of this manuscript were limited to language and readability improvement only, and were not used to generate scientific content, data, analyses, or conclusions, with full responsibility retained by the authors.

References

[1] International Energy Agency (IEA). Buildings. Available from: https://www.iea.org/energy-system/buildings [Accessed May 2025].

[2] Kaassaamani, O. Sustainable Energy Action Plan (SEAP): Kurdistan Region of Iraq, Sulaymaniyah Governorate. CES-MED; 2018. Available from: https://www.climamed.eu/wp-content/uploads/files/Iraq_Sulaymaneyah-Governorate_SEAP.pdf [Accessed May 2025].

[3] United Nations (UN). Division for Sustainable Development Goals. Available from: https://sdgs.un.org/goals [Accessed May 2025].

[4] Mo, H. & Zhou, Y., & Song, Y. Parametric design and spatial optimization of east–west-oriented teaching spaces in Shanghai. Buildings. 2022, 12(9), 1333. https://doi:10.3390/buildings12091333

[5] Song, Y. & Liu, J., & Zhang, W. Design parameters affecting energy consumption of university educational buildings in the hot summer and cold winter area of China. Buildings. 2024, 14(6), 1697. https://doi:10.3390/buildings14061697

[6] Li, R. & Shari, Z. & Abidin, A.B. & Kadir, M.Z. Building orientation effects on HVAC energy performance: educational building analysis in China's hot-summer-cold-winter zone. J Surv Constr Prop. 2025, 16(1), 118–32.

[7] Martinopoulos, G. & Kikidou, V., & Bozis, D. Energy assessment of building physics principles in secondary education buildings. Energies. 2018, 11(11), 2929. https://doi:10.3390/en11112929

[8] Varoğlu, S. & Altın, M. A method developed for determining the optimum orientation and the optimum shading of school buildings in warm climatic regions. Eurasia J Math Sci Technol Educ. 2017, 13(12), 7637–49. https://doi:10.12973/ejmste/80315

[9] Ali-Hasan, N.K. & Abdin, A.R. & El-Deeb, K.M.F. The effects of occupancy, WWR, and orientation on energy use of school buildings in Gaza, Palestine. J Urban Res. 2014, 14(1), 118–29. https://doi:10.21608/jur.2014.92465

[10] Buratti, C. & Belloni, E. & Merli, F. & Mastoori, M. & Sharifi, S.N., & Pignatta, G. Evaluating the impact of shading devices, glazing systems, and building orientation on the energy consumption in educational spaces. Environ Sci Proc. 2021, 12(1), 22. https://doi:10.3390/environsciproc2021012022

[11] Esfahani, H.A. & Momeni, K., & Hassan Pour, F. Finding the best orientation of the educational buildings in hot arid regions in Iran, to achieve the optimum annual energy consumption, using computer simulation (case study: a double class school in Zahedan). Space Ontol Int J. 2020, 9(1), 13–36.

[12] Bakmohammadi, P. & Noorzai, E. Optimization of the design of the primary school classrooms in terms of energy and daylight performance considering occupants' thermal and visual comfort. Energy Rep. 2020, 6, 1590–607. https://doi:10.1016/j.egyr.2020.06.008

[13] Tayib, A.Y. & Hassan, D.K. Investigating interior spaces in primary schools: A case study from Sulaimani City in Iraqi Kurdistan. Sci J Cihan Univ Sulaimaniya. 2024, 8(1). https://doi:10.25098/8.1.26

[14] Zewar, S.S. Contribution to school design through assessment of corridor conditions in foundation schools in Erbil, Iraq. Buildings. 2024, 14(9). https://doi:10.3390/buildings14092678

[15] Swar, S. & Khayat, M. & Amin, A.B.H. The design efficiency of foundation schools in the Erbil Governorate: A study of usable area ratios. ZANCO J Pure Appl Sci. 2016, 28(2), 111–9.

[16] Mustafa, F.A. & Amin, A.B.H., & Swar, S. School design daylighting analysis: A study of foundation schools in Erbil Governorate. Sulaimania J Eng Sci. 2019, 6(2), 21–34. https://doi:10.17656/sjes.10084

[17] DesignBuilder. Designbuilder Software Ltd. v.6.1.0.006. Available from: https://www.designbuilder.co.uk [Accessed June 2025].

[18] Neufert, E., Neufert, P., & Kister, J. Architects' data. 4th ed. Chichester: Wiley-Blackwell; 2012.

[19] Climate.One Building. Climate data repository. 2024. Available from: https://climate.onebuilding.org/default.html [Accessed July 2025].

[20] Kottek, M. & Grieser, J. & Beck, C. & Rudolf, B., & Rubel, F. World map of Köppen-Geiger climate classification. Meteorol Z. 2006, 15(3), 259–63. https://doi:10.1127/0941-2948/2006/0130

[21] Betti, G. & Tartarini, F. & Nguyen, C., & Schiavon, S. CBE Clima Tool: A free and open-source web application for climate analysis tailored to sustainable building design. Build Simul. 2024, 17(3), 493–508. https://doi:10.1007/s12273-023-1090-5

[22] Chartered Institution of Building Services Engineers (CIBSE). Environmental design: CIBSE Guide A. 7th ed. London: CIBSE; 2006.

[23] Ministry of Education of Kurdistan Region. Basic Education School Systems. Kurdistan Regional Government; 2009. Available from: https://gov.krd/moe-en/system-and-education/basic-and-secondary-systems/ [Accessed May 2025].