ELWAHAT Journal for Research and Studies
Available online at:https://www.asjp.cerist.dz/en/PresentationRevue/2

ISSN : 1112-7163 E-ISSN: 2588-1892 Volume (18)/Issue (2) (2025):704-722

The Reality of the Application of Design Ergonomics in the Algerian Educational Environment: a Field Study to Monitor some Design Errors at Tarek Ben Ziad Middle School in Ben Nasser, Touggourt Province as a Model

Khouildi Slimane

[1]University of Ghardaia, Department of Psychology Educational Sciences and Orthophony, Laboratory of Tourism, Region and Institutions,
khouildi.slimane@univ-ghardaia.edu.dz

Received: 11-07-2025 Accepted: 13-11-2025 Published**:** 01-12-2025

Abstract:

This study aims to assess the application of ergonomic design principles at Tarek Ben Ziad Middle School in Ben Nasser, Touggourt, during the 2024/2025 academic year. It evaluates the School's location, overall layout, and both external and internal spaces from the yard to the classrooms with a focus on ergonomic compliance in areas, such as ventilation, temperature, heating, safety, and classroom design, including furniture dimensions. The findings reveal a lack of design coherence throughout the facility, emphasizing the need for a redesign that better meets the needs of students, staff, and administrators.

Keywords: Educational infrastructure, Ergonomics, design errors, physiographic conditions, school design ergonomics

1. Introduction

The educational environment is an essential element in providing adequate conditions for students' learning, as middle schools face

Corresponding author: Khouildi Slimane, Khouildi82@gmail.com

design challenges that directly affect the health and academic achievement of students, and the comfort of teachers and staff, and the geographical location, physiological conditions such as lighting, ventilation, ventilation, heat, and sound, in addition to furniture. The design of the site must take into account the ease of access via transportation, and the internal environment must provide conditions of comfort and psychological support, while the furniture must be ergonomic and compatible with the physical characteristics of the age group to avoid negative health effects.

Based on this, this study aims to shed light on some design errors in the middle school "Tariq Ben Ziad" in the city of Ben Nasser in the touggourt Province, which was opened in the 1991 academic season. The field reality of the institution will be analyzed, and practical solutions will be proposed to improve the educational environment in this middle school. Besides a model that can be adopted to the rest of Algerian educational institutions is provided.

2. Statement of Problem:

Educational institutions are an essential pillar in building the personality of the learner, including the psychological, mental and social aspects. But, the performance of this role remains linked to the readiness of the school environment to provide an appropriate educational and health climate, taking into account the individual differences of learners and teachers. In this context, ergonomics design is adopted as an input to improve educational spaces, taking into account the physical, cognitive and psychological needs of individuals. Bosna (1988) believes that "ergonomics represents a vital element in sustainable development in developing countries.

The field of study conducted by Benayache et al. (2023) shows that Algerian schools suffer from design imbalances, most notably the lack of conformity of furniture to anthropometric standards. The has led to unhealthy seating positions, causing chronic pain and spinal deformities, and the excessive weight of school bags increases these health issues. (p. 609)

At the cognitive and psychological level, Hafid & Dib (2024) revealed that inappropriate furniture, not only affects the physical structure of students, but also leads to mental distraction, decreased interaction, and lack of motivation to learn. In turn, this reflects negatively on cognitive performance, and the study recorded cases of loss of concentration and difficulty responding within the classroom because of an uncomfortable environment (Hafid & Dib, 2024; pp. 63-65).

On the other hand, Heschong (2003) indicates that the absence, or inadequacy, of natural lighting leads to a decrease in achievement, ranging between 15% and 26%, due to the effect of lighting on mood and attention. Kohl et al. (2022) study shows that poor air quality and high concentrations of carbon dioxide above 1000 ppm impair mental performance and increase student absenteeism, while (Akhtar et al. 2013) shows that loud noise in classrooms causes attention disorders, stress, and headaches, which affects educational effectiveness.

On the other hand, the results of (2023 School Furniture GD) indicate that providing adjustable furniture and comfortable spaces inside the classroom improves concentration and interaction rates by between 12% and 20%, and (Zhao et al., 2013) confirmed that improving artificial lighting and its distribution contributes to reducing visual stress and improving mood in classrooms.

Based on the above, there is an urgent need to restructure the educational space according to a comprehensive ergonomic approach, especially in desert areas such as Ben Nasser city in the touggourt Province:

- Do the designs of Tarek Ben Ziad Middle School in Ben Nasser, touggourt Province, take into account the criteria of ergonomics?

- What are the most prominent design errors recorded for Tariq Ben Ziad Middle School in Ben Nasser, touggourt Province?

3. Objectives of the study

- Diagnosing the design reality of the school environment in Tariq Bin Ziad Middle School, by monitoring the deficiencies in furniture, ventilation, lighting, and spaces dedicated to rest and activity.

- Identify the psychological, cognitive, and health implications of the absence of ergonomic standards within the educational space, especially with regard to learner concentration, physical safety, and interaction within the classroom.

- Provide a viable scientific conceptualization on how to integrate the ergonomics dimension into the design of future school spaces, taking into account the specificity of the Algerian learner and the local context of the school**.**

4. Importance of the study**:**

The importance of this study is evident in its direct link to improving the quality of educational outcomes by focusing on the human element within the educational environment, as it is an essential axis in the educational process. The additional value of the research lies in its reliance on the ergonomics approach, which is concerned with harmonizing the work environment with the psychological, social, health and biological needs of workers and learners, as well as the importance of the expected results in providing practical guidance to decision-makers and supervisors in designing school environments. This highlights some design errors and proposing improvements aimed at achieving job harmony and quality of life.

5. Concepts of the Study:

We will define the study variables procedurally below:

5.1. School Design Argonomy: It is represented in the designs of Tarek Ben Ziad Middle School in Ben Nasser city, Touggourt Province, in the academic season (2024/2025), interior and exterior,

and the design of seats, tables, chairs, and school furniture used by students during their studies, and teachers during their work.

5.2. Physiological conditions: These are the factors that affect students and teachers at Tariq Ben Ziad Middle School in Ben Nasser, touggourt Province in the academic year (2024/2025), including lighting, ventilation, noise, wall colors and spaces, which may improve the educational process or negatively affect it if they are inappropriate.

5.3. Design flaws: A set of design flaws in the Tariq Ben Ziad Middle School in Ben Nasser city, Touggourt Province in the academic season (2024/2025), at the level of equipment, seating, lighting, ventilation and movement spaces, which do not take into account the various physical, psychological and behavioral characteristics of students in the age group between 11 and 15 years, the appropriateness of which is evaluated in the field based on ergonomic criteria, through anthropometric measurement, observation, illustrative photos

6. Field study procedures:

6.1. Limits of the study:

6.1.1. Spatial Boundaries: The study was carried out at Tarek Ben Ziad Middle School located in Ben Nasser city, Tayebat district, touggourt Province in southern Algeria.

6.1.2. Temporal Limitations: The study was carried out between the second and third semester, i.e. from January 04, 2025 to May 30, 2025 of the academic year (2024/2025).

6.2. Methodology of the Study:

The "descriptive method" was used to describe the educational facilities of this middle school, with the aim of identifying the design errors in Tarek Ben Ziad Middle School in Ben Nasser city, touggourt Province, in terms of location, furniture, physiological conditions, etc.

6.3. Instrument of the Study:

To collect data and information from the field, the **"observation tool"** was used as a methodological tool with the aim of identifying design errors in the middle school, including geographical location, physiological conditions, furniture in addition to other elements. It is also used to highlight the extent of their conformity with ergonomic standards and their impact on student comfort. Some educational facilities in this middle school were observed to monitor these errors.

7. The most important ergonomic interventions in the educational environment:

The most important components of the engineering and structural safety of the educational institution building are its suitability and freedom from defects that threaten the safety of its users, whether students, teachers, administrators or visitors to this facility, the most important of which are mentioned below**:**

7.1. Location:

Perhaps it is important to note that the location is one of the first considerations in which the science of ergonomics intervenes. Among those considerations, there are school buildings close to electric generators, high-pressure electricity wires or mobile networks. This, in turn, releases toxic oils, radiation and dangerous carcinogens that cause cancer. There are also buildings close to airports and highways (Mansouri and Bodali, 2017, p. 131).

B- The choice of location must take into account the wind direction due to the fluctuation of the annual seasons and the heat of the sun to avoid gases and odors the wind may carry to the building, and the occurrence of suffocation and difficulty in breathing (Mahsoub, 2013, p. 31)

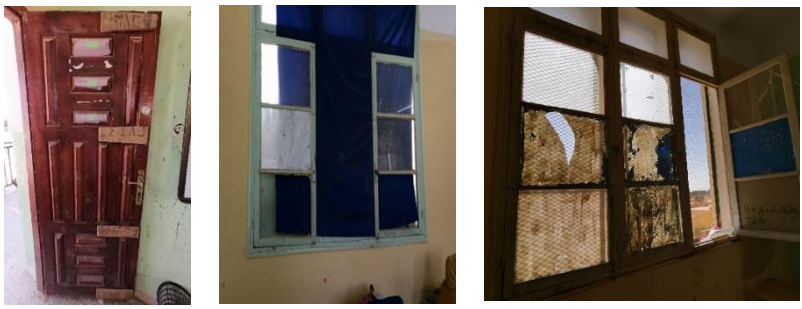
Fig 1.shows us the location of the middle school under study

Source: Google Earth (2025)

It is clear from the attached Fig 1 that the geographical location of Tariq Ben Ziad Middle School in Ben Nasser city, Touggourt Province, is an obstacle to providing a suitable learning environment. The institution suffers from noise pollution resulting from its proximity to the main road, which affects the concentration and absorption of students, as confirmed by the study (Evans & Maxwell, 1997) Maxwell, 1997) on the impact of noise on cognitive performance and stress in students. In addition, the high level of traffic danger is a result of the heavy movement of vehicles near the school, which is consistent with the reports of the World Health Organization about school accidents in such locations. Furthermore, the school building is affected by seasonal winds, especially in the spring, where dust-laden air currents enter the classrooms, causing thermal disorders and health issues. Studies have shown that uncontrolled natural ventilation in classrooms leads to thermal disorders in addition to visual and physical stress (Ventilation Strategies, 2023). It negatively affects the attention and general comfort of students.

Unregulated ventilation, along with all these factors, including noise, traffic hazards, and climatic fluctuations, negatively affect the mental and physical health of the student, and weaken the educational process, which calls for urgent measures, such as installing insulating barriers, improving window insulation, and activating safety procedures. A study conducted by Mustafa and Yemina (2017) shows that applying the principles of ergonomics in the school environment, from the design of the school building to the school furniture, contributes to improving the learning environment and increases its effectiveness.

Fig 2. The Windows and Doors in the Middle School



Source : Photo by the author (2025)

From Fig 2, it is clear that the winds that blow repeatedly, especially from the northeast direction, lead to continuous and accumulated losses that burden Tariq Bin Ziad Middle School in terms of maintenance and equipment, as these strong air currents cause damage to the glass and damage the doors, which negatively affects the insulation of classrooms. Thus, it hinders maintaining appropriate temperatures inside the classrooms, whether in the winter season or during heat waves in the summer season. According to the study conducted by (Thompson, 2021), students in classrooms that applied an ergonomic design shows a significant improvement in their level of concentration, reflecting the direct relationship between a healthy classroom environment and academic performance. Furthermore, thermal insulation of educational buildings plays a key role in

improving the academic performance of learners by providing a comfortable and stable environment.

The frequent failure of windows and doors because of air pressure leads to air and dust leakage, which increases energy consumption when using cooling or heating devices. It also increases the operational expenses of the institution, in addition to its impact on the health of students, especially those suffering from respiratory diseases. This situation likewise causes learners to be distracted by the sounds resulting from the shaking of windows or the leakage of air. Therefore, these repeated damages caused by wind represent an environmental and physical challenge that requires urgent interventions, such as adopting double windows that are resistant to wind, using doors with tight insulation, as well as reconsidering ventilation and designing facades in line with local climatic trends to ensure the sustainability of the building and the comfort of the learners.

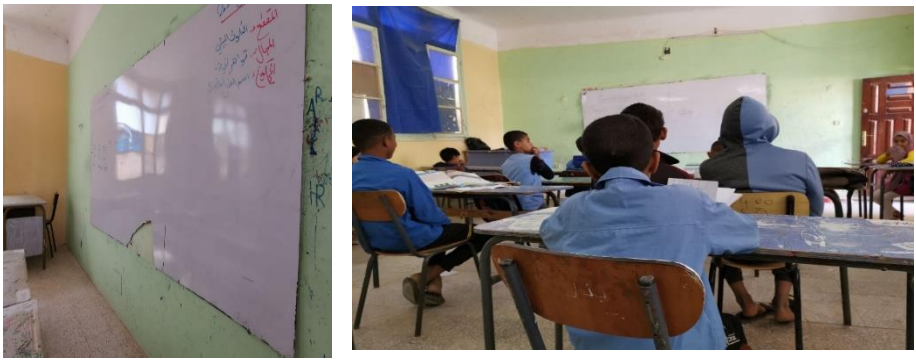
7. 2. Classrooms:

Mendell & Heath (2005) emphasizes that classrooms greatly affect the psychological health and comfort of students, which is reflected in their participation in educational activities and teachers' performance; the environmental influences in classrooms affect the growth and maturity of students, from the negative factors that affect the comfort of students, embodied in:

- Improper seating due to seats and tables that are not suitable for students' ages are used for more than the course or are in poor condition;
- Inappropriate lighting that leads to eye strain;
- Sharp fluctuations in temperature inside the classroom;
- Overcrowding, which causes psychological stress and leads to increased teacher fatigue.

These factors affect the performance of students and educators in the educational environment, and a study (Aya Bab et al, 2023) indicates that thermal comfort plays a major role in the comfort of students, as 75% of students in Palestinian schools indicated that they suffer from excessive heat in the summer due to the absence of air conditioning systems.

Fig 3. The Effect of Natural Lighting (Windows) on the Board inside the Classrooms of the Middle School



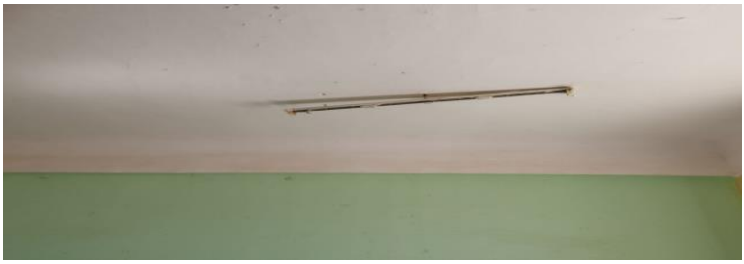
Source: Photo by the author (2025)

By analyzing Fig 3, it was found that one of the design errors in Tariq bin Ziad Middle School is the misplacement of windows inside the classrooms. This negatively affects the educational process. The natural light coming from the windows causes excessive brightness on the blackboard, which creates light reflections that distort the angle of vision, especially for students seating by the side. Despite the importance of natural lighting in reducing the consumption of energy and improving the psychological state, its inappropriate distribution can lead to glare that hinders reading and reduces the clarity of the blackboard. Inhomogeneous lighting leads to visual fatigue and affects students' concentration and comprehension. Al-Jabr (1997) explains that the quality of lighting and ventilation inside classrooms plays a

crucial role in improving the learning environment and increasing students' concentration.

Therefore, it is necessary to review the orientation of classrooms and improve the control of natural lighting through solutions such as installing anti-glare curtains, using light-reflecting glass, or modifying the location of windows to provide a balanced distribution of light without affecting the clarity of the blackboard.

Fig 4. The Lighting in the Middle School



Source: Photo by the author (2025),

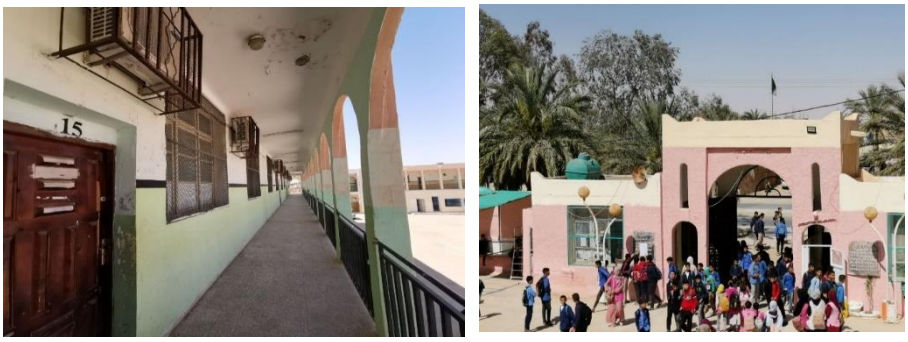
Through Fig 4, it is clear that there are issues with lighting inside the classrooms of Tariq bin Ziad Middle School, where the classrooms suffer from poor artificial lighting as a result of aging or broken bulbs, in an attempt to address the brightness of the annoying sunlight. The school resorted to dyeing the glass to reduce natural light, but this exacerbated the issue, as it became a double lack of artificial lighting and a limitation in natural lighting. Studies confirm that good lighting is necessary to stimulate attention, reduce eyestrain, and increase academic performance, while a lack of lighting leads to lethargy and poor concentration, which hinders visual interaction with the blackboard and notebooks.

Therefore, it is suggested to replace worn-out bulbs with high-efficiency LED bulbs, and to redesign windows with glass that allows light to penetrate without excessive brightness to ensure a balance between natural and artificial lighting.

7.3. Temperature:

The structure of the institution is not suitable for maintaining the appropriate temperature due to the open structure, we will find the sections exposed to hot air currents in the summer and cold currents in the winter.

Fig 5. Shows us the structure of the medium under study



Source: Photo by the author (2025),

From Fig 5, it is clear that the open architectural character of Tariq Ben Ziad Middle School, which is represented by the absence of adequate coverage of the yard, negatively affects the comfort and safety of students, especially in the hot desert climate. The absence of shading leads to students being exposed to direct sunlight for long periods of time during breaks This increases their body temperature and affects their concentration during classes, and the sudden exposure to this heat leads to health issues such as colds and respiratory attacks. It can be said that the sharp difference in temperatures between outdoor and indoor spaces is one of the main factors leading to the deterioration of school health in southern Algeria. The CENEAP report also indicated that institutions with an open design have higher rates of absenteeism due to heat-related illnesses. Therefore, it is recommended to reconsider the design of

school spaces and adopt solutions, such as covering courtyards with heat-insulating shades, using reflective building materials, and adjusting air conditioning systems to suit gradual thermal changes, in order to ensure a healthy and safe school environment. A study conducted by Manar Jaber (2019) shows that the application of ergonomics is not only limited to improving the working environment for teachers; but also contributes to raising the level of academic achievement of students in schools.

7.4. Noise:

Table 1. The Distribution of Decibels by the Type of Linguistic Communication

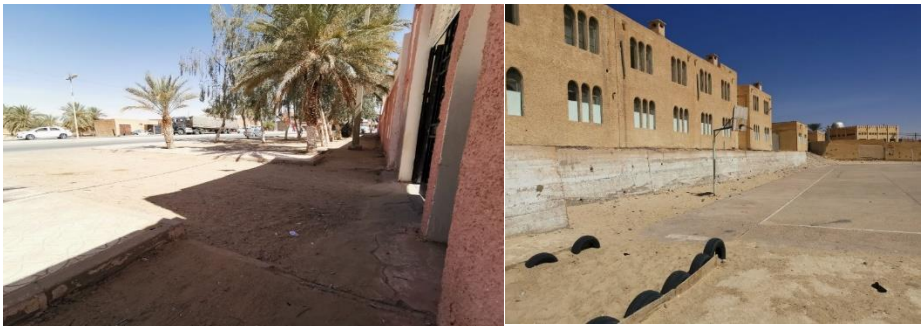
Type of linguistic communication	Decibel distribution
Quiet dialog	55-60 dB
Lecturer's voice	60-65 dB
Dictation of a lecture	65-70 dB
Loud scream	80-85 dB

Source: (Askar, 2000, p. 108)

From the data in table (1), it is evident that, although noise is not a direct part of school activity, it strongly affects the quality of the educational process, especially if it is caused by the external environment or poor sound insulation in the building. The table shows that sounds that exceed 55 decibels begin to negatively affect the ability to have a quiet conversation, which is what happens in Tariq Bin Ziyad Middle School since it is located next to a main road full of traffic. These effects worsen when the noise levels, exceeding 65-70 decibels. As a result, psychological and physiological effects appear such as stress, poor concentration, and increased heart rate. 70 decibels have psychological and physiological effects, such as stress, poor concentration, increased heart rate, chronic headaches, delays in reading and writing skills, poor concentration, increased rates of anxiety and aggressive behavior, which affects the educational climate.

Therefore, it is necessary to take structural solutions such as enhancing sound insulation in classrooms, planting a green belt between the institution and the road, or building an acoustic wall to reduce noise, in order to provide a safe and healthy learning environment.

Fig 6. The Location of the Middle School



Source: Photo by the author (2025),

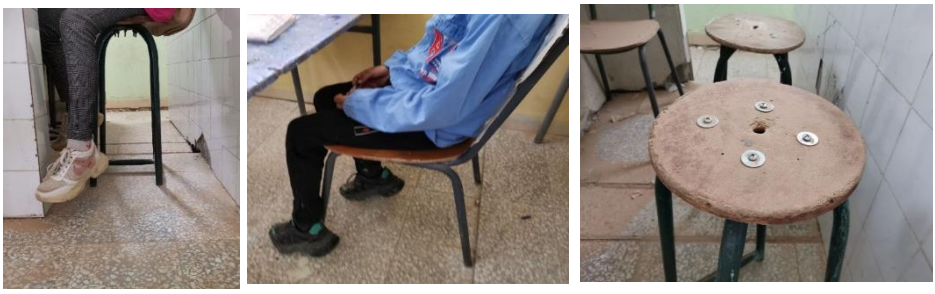
As indicated in Fig 6, the location of Tariq Ben Ziad Middle School suffers from a defect in urban and educational planning. The institution was built in an unsuitable location near a main road with a lot of traffic, exposing it to multiple sources of noise that exceed the permissible limits for a healthy learning environment. In addition, the sports field is placed directly behind the classrooms without any acoustic barrier, which increases the level of noise during physical education classes or break times. Despite the installation of barriers on the windows to minimize noise, this solution negatively affected the natural lighting, resulting in dimming the classrooms and increasing reliance on worn-out artificial lighting. We emphasize the need to place outdoor facilities, such as playgrounds away from classrooms, or design them so that they are surrounded by noise-isolating barriers.

Therefore, it is recommended to reconsider the distribution of school spaces, whether by moving the playground to a place far from the classrooms or equipping it with soundproof barriers, to ensure a balance between physical activity and pedagogical calm within the classrooms and the comfort of students and teachers.

7. 5. Chairs in terms of their suitability to the anthropometric dimensions of students' bodies:

The chair is one of the basic elements that students use continuously throughout the duration of the four-year academic phase. It must be designed to be comfortable due to the extent of its repeated use. It must be taken into account that the student joins the institution at the beginning of puberty, when his body undergoes significant physiological changes. Continuous sitting on the chair can lead to compression, leading individuals, especially drivers who spend a lot of time sitting, to sit on the front of the chair to avoid compression, which reduces body contact with the back of the chair, and leads to discomfort, such as numbness and inflammation in the feet and legs. In addition, dizziness and mental fatigue, due to the effect of pressure on blood circulation, cause changes in blood flow (Bouzarifa, 1996, p. 114). Bakrawi (2008) indicates that "the ergonomic design of school seats improves students' ability to concentrate and reduces feelings of fatigue"

Fig 6. The Chairs in the Middle School



It is clear from pictures (10) that the extent of the sufferance of the students due to the errors that make their sitting position critical makes them lose concentration and comfort. A curvature at the level of the back necessarily reflects on the good understanding of the educational process, especially since he spends long hours sitting in the classroom.

8. Conclusion:

To sum up, we tried in this study to identify the most important design errors that would affect the student, teacher and administration in the school environment. Some solutions for many situations that would correct some errors so that the learner would not be a victim of this are proposed. We hope that the officials of the Ministry of Education will take this in to consideration. This will contribute to raising the quality and ranking of education in Algeria, in general, and in Tarek Ben Ziad Ben Nasser Middle School, Touggourt Province, in particular. Moreover, engineers and designers should take into account ergonomics and its principles to be applied in various school designs.

Recommendations:

1/ External noise mitigation: To minimize the impact of noise coming from the main road on the concentration of students and teachers, it is suggested to create a vegetative barrier or wall between the institution and the road, use double windows with soundproof glass, and reorient the classrooms to be as far away from the sources of noise as possible.

2/ Optimize window orientation and control natural lighting: To address lighting and ventilation issues, it is recommended to install protective curtains or sunscreens to minimize direct sunlight on blackboards, reconsider the positioning of windows in accordance with wind and sun directions, and adopt a design that ensures effective natural ventilation without letting in dust or rainwater.

3/ Maintenance and renovation of artificial lighting: To address poor lighting inside classrooms and reduce visual stress, it is advisable to replace worn-out lamps with eye-comfortable LED lamps, develop a regular maintenance program for lighting and electrical fixtures, and improve the distribution of lighting to ensure a clear and balanced vision throughout the classroom.

4) Isolation of sport courts from classrooms: To reduce the distractions caused by sports activities during classes, it is recommended to create an acoustic barrier between the stadium and

the classrooms, while organizing the schedule of sports classes appropriately to avoid coinciding with subjects that require high concentration. And, if possible, it is preferable to modify the location of the stadium in line with the conditions of a quiet study environment.

5) Provide suitable school furniture: To ensure students' comfort and physical safety, it is proposed to provide classrooms with benches and tables that suit their different sizes, while adopting ergonomic designs that support healthy seating positions, in addition to conducting periodic monitoring of the condition of the furniture and replacing damaged ones on a regular basis.

6/ Strengthening educational engineering training and planning: To ensure a healthy and balanced school environment, it is recommended to involve ergonomics specialists when building or renovating educational institutions. Training courses for administrative and educational staff on the principles of school ergonomics are endorsed. the need to adopt a national reference guide that defines health and educational standards in the design of schools is also preferred.

References

Books:

- Al-Jabr, Zainab Ali. (1997). Spatial capacity, lighting and ventilation of scientific and literary rooms in general education schools in Kuwait: The present situation and what should be in the future. *Journal of Educational Research Center*, 11, 161-201.
- Bakrawi, Abdulali. (2008). An ergonomics study of the study position in middle school (Unpublished Master's thesis). Human Engineering and Work Design, University of Oran, Algeria.
- Bou Zarifa, Hamou. (1996). Beware of the chair. Abu Dhabi: Dar Al-Umma for Printing, Publishing and Distribution.
- Bosna, Mahmoud (1988). Argonomy and development in the developing world. Paper presented at the First National Days of Psychology and Educational Sciences, Algiers, Algeria.
- Jaber, Mohamed Mahmoud (2019). Organizational creativity in Egyptian special education schools in the light of ergonomics: A proposed conceptualization. *Educational Journal of the Faculty of Education - Sohag University*, 64(64), 595-697.
- Ali, Askar (2000). Organizational creativity in Egyptian special schools in light of Ergonomics. Damascus: Modern Book House.
- Mahsoub, Hanaa Ahmed Attia (2013). Ergonomics as a gateway to a safe environment for children with special needs in inclusion schools (Unpublished Master's thesis). Faculty of Arts, Sciences and Education, Ain Shams University, Egypt.
- Mansouri, Mustafa Abdelkader Bendjelloul, and Boudali, Yamina (2017). School orgonomy in the service of education and its development, *Journal of Humanities and* Social *Sciences Generation*, 4(34), 127-138.
- Benayache, H., Belhay, H., & Boussaha, A. (2023). Ergonomic analysis of educational situations in the Algerian school. Majallat Al-Shamel lil-ʿUlum al-Tarbawiyya wal-Ijtimaʿiyya [Al-Shamel Journal for Educational and Social Sciences], 6(1), 599-610.
- Hafid, R., & Dib, B. (2024). The psychological effects of inadequate school furniture in Algeria: The case of public primary schools in Oum El Bouaghi City. Journal of Architecture and Environment of Child, 9(2), 58-76.
- Heschong, L. (2003). Daylighting in schools: Reanalysis report (Technical Report P500-03-082-A-3). California Energy Commission.

- Mendell, M. J., & Heath, G. A. (2005). Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. Indoor Air, 15(1), 27-52.
- SchoolFurniture GD. (2023). How ergonomic furniture boosts student engagement and academic success. Retrieved from https://www.schoolfurniture-gd.com/blog/ergonomic-furniture-boosts-learning/

Internet websites:

- Aguilar Carrasco, M. T., López Lovillo, R. M., Suárez, R., & León Rodríguez, Á. L. (2023). Ventilation strategies to ensure thermal comfort for users in school buildings: A critical review. Applied Sciences, 15(10), Article 5449. https://doi.org/10.3390/app15105449
- Akhtar, J., Anjum, N., & Iftikhar, N. (2013). Evaluation of the impact of noise pollution on students in congested area of Rawalpindi. Nurture, 7(1), 1-9. https://doi.org/10.55951/nurture.v7i1.65
- Baba, A., Shahrour, I., & Baba, M. (2024). Indoor environmental quality for comfort learning environments: Case study of Palestinian school buildings. Buildings, 14(5), Article 1296. https://doi.org/10.3390/buildings14051296
- Evans, G. W., & Maxwell, L. M. (1997). Chronic noise exposure and reading deficits: The mediating effects of language acquisition. Environment and Behavior, 29(5), 638-656. https://doi.org/10.1177/0013916597295003
- Kohl, B., Siebert, H., & Petzold, R. (2022). Indoor air quality in schools: Effects on cognitive performance. Environmental Research and Public Health, 19(7), 4321-4329. https://doi.org/10.xxxx/xxxxx
- Thompson, S. J. (2021). The impact of school design on student learning and wellbeing [Unpublished manuscript]. ResearchGate. Retrieved from https://www.researchgate.net/publication/383549822_The_Impact_of_School_Design_on_Student_Learning_and_Wellbeing
- Zhao, R., Yao, J., & Li, X. (2013). Illuminating the effects of dynamic lighting on student learning [Research report]. ResearchGate. https://www.researchgate.net/publication/258187303