Post Occupancy Evaluation for Sustainable Learning Environment
Identifying the Factors Affecting Learning Environments in Education Facilities (Specific Reference to Primary School Students)

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A R T I C L E   I N F O

A B S T R A C T

Learning environment refers to the physical context and the circumstances that students experience during their learning process. One of such settings is in the classroom. Most Egyptian schools have lacked an efficient classroom design that supports students learning process. It lacked the comfort conditions, which influence students' interactivity and focus. Thus, an in-depth analysis is needed to determine areas that could be enhanced in classroom design. Post Occupancy Evaluation (POE) system is a tool for evaluating building's performance after it has been put to use. It allows facility managers to test and notice any areas where improvement is needed. Hence, this paper aims to identify and understand the physical factors that affect students' performance, using POE techniques. The adapted methodology is a deductive qualitative method in two sections. The first section is in-depth literature that determine the factors affecting student performance using POE. Two methods are applied for data collection, which are a students' survey, and a walk through survey. The second part is an applicable study to examine deducted performance factors through a comparative analysis between an international case study from New Zealand and a national one in Egypt. The findings of the research will provide guidance to enhance the learning environments, and students' performance in existing classrooms in Egyptian public schools.

1. Introduction

An adult or child gains their information, understanding, personality, abilities and experience through their educational journey. Education process includes nursery schools, primary-elementary schools, secondary-high schools, and universities. It creates a person polished, educated, civilized and cultured.it is the only means for a socialized and civilized society [1]. It is estimated that by the year 2020, the population of Egypt will rise to 92 million people. This means that there will be an increase in the number of students at each learning stage, which will be a serious problem for that generation. [2]

The learning environment is defined as the different areas, circumstances, experiences and lifestyles that the students get in contact with during their learning experience. The objective is to produce a suitable learning environment for students to learn. The direct and indirect effects that learning environments have on the students' performance, whether it's their understanding of topics, their participation, feeling welcomed, their energy, sense of security and well-being during classes is a controversial topic. [3]

Post Occupancy Evaluation is "a structured review of the functional, operational and strategic performance of the building during the occupation". It is a process of collecting data and analyzing the building's performance after it has been used. Those include the building's technical data, energy consumption, occupier behavior and whether or not the spaces are well designed. This is critical for maximizing the occupier productivity without wasting any resources. [4]

Ways by which POE is done include:

- Walk Through and Observation of the surrounding
- Interviews
- Focus groups
- Workshops
- Questionnaires and surveys. [5]

1.1. Post Occupancy Evaluation (POE)

The below section of the paper will be an explanation of the POE process. The different definitions of POE will be mentioned. Then, the history of POE will be discussed and after that, the purpose of the process will be explained. Later, the different types of POE will be noted. Finally, a summary will be made of the section to conclude it.

1.1.1. Definition of Post Occupancy Evaluation

According to Preiser (1988) one of the definitions of POE is that it is a process that is done after the building has been put to use. This process is an intense and planned practice that is used in evaluating the buildings. In 1991, The RIBA, Research Steering Group, defined POE as a procedure that gives information about the performance of designs and building

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owners and users given to the architects with instructions to accomplish the best of what they have. Another definition of POE defined by Preiser (1995) is that it is a diagnostic application that helps the facility managers to find and assess the essential areas of the building performance. Moreover, Vischer (2001) mentioned that POE is all of the activities derived from the interest for knowledge about the building performance and how it will satisfy the user's expectations.

1.1.2. History of Post Occupancy Evaluation

Over the years, a number of researchers used POE as a device for evaluating, improving and documenting a building as environmental situation. They agreed that POE must be part of process of performance procurement of the building. [6] Post occupancy evaluation began in the United Kingdom when local governments and the British Ministry of Education collaborated to initiate taking estimations of building in the post-World War II period. [7] Using POE as a measuring tool on any building will reveal which component in a building underperforms, and which component performs well, affecting the employees' productivity and satisfaction. [8] According to Riley (2010), the rapid housing development that was due to World War II led the architects to use Poe in building environments. Kirk and Stirrett (2011) described POE as a treatment for the building and is considered a formal study and testing if the building achieved the targets and goals set in the main program.
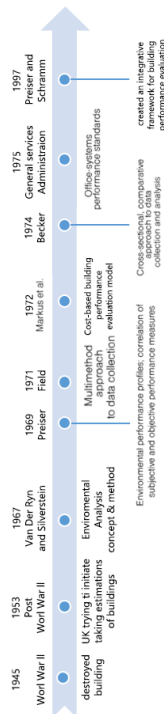

Figure 1: Timeline of evolution in the POE (Mahfouz, 2017)

1.1.3. Purpose of Post Occupancy Evaluation

Baird, G. (1996) mentioned in his introduction to his book 'Building Evaluation Techniques' a range of purposes that he suggested for performing the POE:

- Reducing the occupancy costs.
- The satisfaction of users has increased.
- Enhanced productivity within the workplace.
- Better linkage of supply and demand.
- Certainty of decision-making and management.

- Higher returns on operation in people and buildings. [9]

1.1.4. Types of Post Occupancy Evaluation

The figure below shows the model of the POE process. It shows that the process of evaluation consists of three main levels. Nine sublevels are repeated under each level until the evaluation is done.

- Indicative POE provides a signal of weaknesses and strengths for the performance of the building. By implementing this procedure, it facilitates the collection of information.
- Investigative POE is starting to investigate and exposing the problems whenever recognized. The information will be presented for a solution once the process has been achieved.

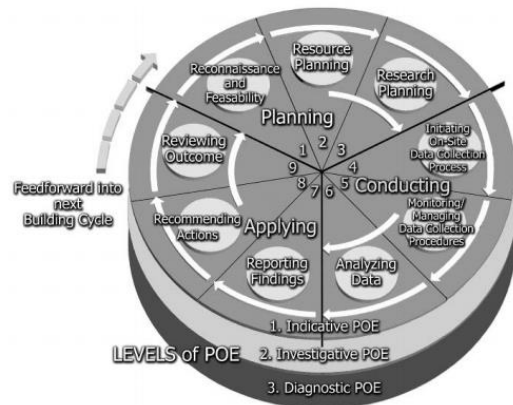Diagnostic POE is combining subjective occupant response measures with physical environmental measures.

Figure 2: Evolving performance criteria of the Post Occupancy Evaluation [10]

1.2. Schools as a learning environment

This part of the paper will be discussing all the gathered information from the sources obtained from previous researchers about the schools and how they can affect the students' performance. First, the history of schools in Egypt will be mentioned. Next, the needs of the primary school students will be discussed. Later, the different environmental factors that affect the student performances will be mentioned and explained. Finally, a concluding summary of this section will be made.

1.2.1. Students' needs in primary schools

According to the (Egyptian Ministry of Education, 2016), children start to build their character at a very young age. A child spends a long time at school, which is the reason why schools have a major impact on forming the children's character. As an example, the ministry of education in Singapore made sure that the schools improve for every child their education and enables them to grow into the following:

- A self-taught student, who is able to persevere, asks, reflects and is responsible for his own study.
- An active member who is qualified for takes risks of calculating, endeavor for excellence and work productively in teams.

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- Be a confident person who is resilient and adaptable, communicates productively, thinks critically and has a sense of knowing the wrong and right.

1.2.2. *Classroom Environment and how it impacts the students' performance*

A school classroom is a place where students spend a large amount of their time. It is where a student learns different skills, which are important and necessary to achieve future success in society. It is essential to understand the ways that affect children in the classroom environment to achieve maximum performance in the learning process. There are different factors that affect a student learning process including lighting, color, seating arrangement, classroom furniture, and noise. The diagram below shows those factors.
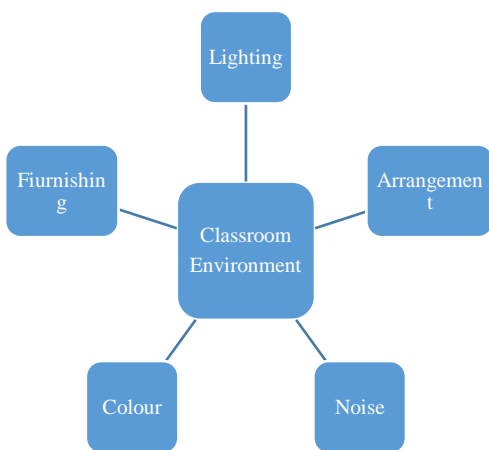

Figure 3: Classroom Environment Factors

Codes were adopted to ensure maximum benefit of the surrounding. Egypt has a code (No. 204-2015) for educational buildings establishments that states factors and elements for designing schools.

LIGHTING

Proper natural light aids in the creation of physical senses and other mental features that are mainly related to the comfort of people. Its advantages seem to be more difficult than expected of being an aid to sight. The ceiling that is designed to be with a low level in classrooms can be the sources of pupils to feel gloomy as the changing in levels of light between the inside room and the side next to the windows has a huge effect on this theory. Thus, the daylight from natural sources must be the major element that provides lighting in schools. Generally, the important necessities to have efficient daylight in the system of schools can be accomplished by completing the following concepts:

- Proper arrangement of the building to ensure having enough light.
- Spaces including both library and art classrooms must also be located in a position where the daylight can be effective.
- Decent distribution of the daylight by assigning large windows that are positioned at the top of the wall that would bring the lights into deeper positions and spaces.
- These considerations will reduce the effect of glare as the light is generated from different sources.
- Shading controls are important in the system that has many windows. [11]

DIFFERENT TYPES OF CLASSROOM LAYOUTS

Classrooms' arrangement of the desks and chairs of students is one of the requisite variables that can be changed. According to [12] in their research that compares tables and rows, 26 of less attentive and less successful students are affected by the arrangement of desks. The students' behavior increased when changing the seated arranged from tables to rows. These authors mentioned that the relation of element of vital mediating between enhanced classroom medium and the physical environment could decrease in negative communications between student and teacher. Moreover, in rows arrangement the pupil is capable of focusing and getting less reprimand.

Depending on the student's position, there will be various involvements. It increased in an "action zone" in the middle of the room along the front and down from it. According to [13] [14] there is a compact about the presence of a zone as shown in figure below. However, there is an argument about wither the triangular shape or the "T" shape is more accurate. [15].
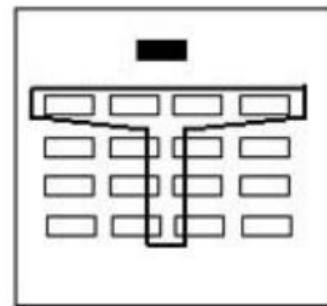

Figure 4: Action zone diffuse away from the instructor [15]

Figure 5: Horseshoe-shaped desk arrangement

It is most likely that students are sat around tables in primary schools so that they can work in groups. They recommend the form of horseshoe, which allows the students to face each other and see the teacher. Galton et al (1999) also agreed with them and recommend the horseshoe arrangement. On the other hand, Horne-Martin (2002) said that it is a controlling method by teachers and very restricted formation for students.

NOISE

Children in school face many different sources of noise. Classrooms are exposed to noises that come from external noise moving through the envelope of the building and creating the disturbance along with the other internal noises that are made. Environmental noises are responsible for external noise such as industrial noise, transportation sources, and the noise coming from outside the school from people, plant noise and the rain falling above light school roof. These sources are responsible for disturbances in teaching. [16]. A survey made

by Dockrell and Shield (2003) in London about the sources of noise outside schools observed that the prevailing noise sources were 11% of schools face noise from railway, 24% from buses, 35% from trucks, 54% from aircraft, and 86% from cars outside schools. Those percentages agreed with the ones that were obtained by the National Noise Incidence Survey that was done on houses in the UK in 2000-2001. The survey showed that 12% of the houses were subjected to noises coming from the railway and 87% of the houses were subjected to traffic noise. [17] Therefore, the results obtained about houses can also be used to know the levels of noise that schools are exposed to as they are usually in the same areas. The following figure shows percentages of noise sources.
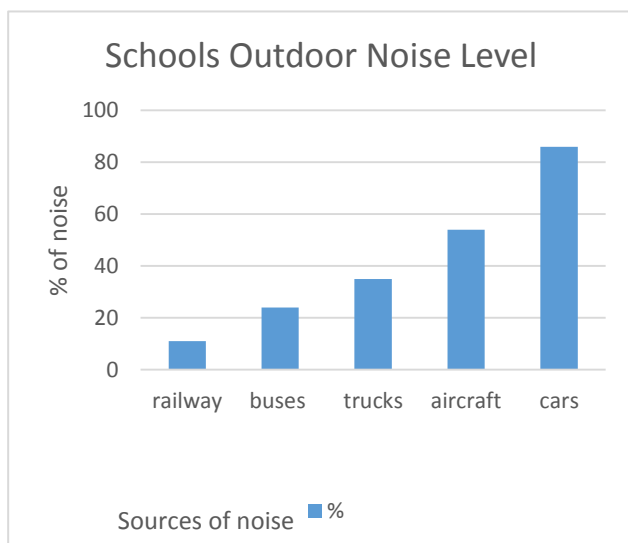

Figure 6: Outdoor noise levels of schools in London

COLOURS

Some studies show that colors may have an impact on the behavior and mood of surroundings. Brubaker (1998) mentioned that cool colors help children focus. While (Read et al, 1999) believe that ceiling height and color can have an impact on the cooperative attitude of children. Moreover, Engel Brecht (2003) added that wall color affects the accuracy and productivity of students.

Figure 7: Classroom with cool colors

FURNITURE AND EQUIPMENT

While furniture comfort has been researched in the workplace, it has been neglected in school classrooms. When classroom furniture was more ergonomic, it was found that student performance improved. [18] However, in some cases, that did not work because the children were not taught how to use the ergonomic furniture properly. [19] Moreover, there was no difference in back pain levels when using ergonomic furniture. [20] The problem was not solved because the furniture was not suitable for the children's heights and it was learned that the popliteal height should be used when designing the furniture instead of the overall height. [21] Another reason for back pain was the heavy backpacks that the students carried. To solve that, lockers were made, however they did not fully solve the problem. [22]

1.3. Purpose and benefits of POE for school buildings

The stakeholders' needs can never be fully covered in any school building. That is because what actually happens is that the clients, architects and builders usually meet together to discuss the different designs of the school buildings. However, the building users are not involved in those meetings, leading to the final design lacking their actual needs. The legal authorities then evaluate the school buildings and notice some imperfections. Thus, it is understood that the schools' environments should be improved on a continuously by effectively using the available resources. [23]

- Enhancing the future's building designs. The most significant result is identifying different sides of new schools, which conduct the buildings' evaluations in a school building arrangement at the early phase.
- Showing preferable value. Identifying the equipment that is required for the efficient purpose and appropriate costing by using building evaluations.
- The stakeholder's commitment to building. Users participate in evaluations to discover how the building functions and find out how well it works leading to support the educational culture
- Current buildings evaluation. As a necessary method in refurbishment projects planning, methodologies of evaluation of buildings can be utilized in the current schools. [23]

2. **Case Studies and materials**

Below are the selection criteria for choosing the case study:
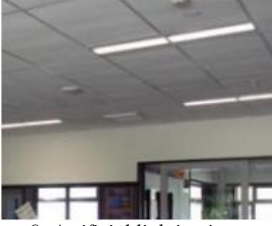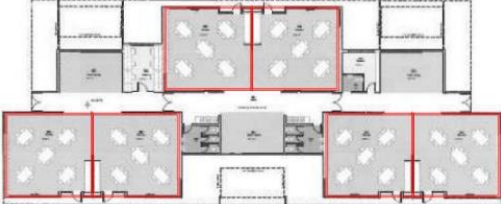
- Primary public school
- International case study for analysis and national case study for application
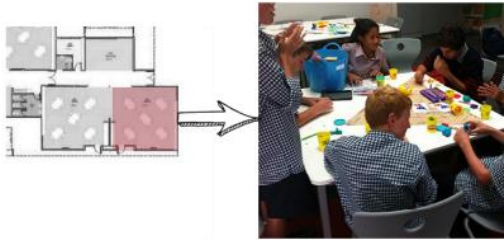- Application of Post Occupancy Evaluation

2.1. International case study: Amesbury Primary School

2.1.1. Background information

The School is located in Wellington, New Zealand. It is constructed in January 2012. It provides learning areas that can occupy 400 students. The vision of the school was to make open plan linked with outdoor areas with clear sightlines and daylighting [24]

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2.1.2. Case study Analysis

Classroom Environment		Analysis
Lighting	Natural daylighting	Windows in classroom are wide, which allow the maximum solar gain to enter the space. Although, the height of the window extended to a greater altitude with a functional depth to provide illumination with daylight [24] *Figure 8: Wide windows in one of the classrooms. Source [24]*
	Artificial lighting	According to the observations team, the artificial lighting was Distributed and appeared effectively through the time of evaluation. 70% of responses announced that lighting was 'quite sufficient 'or 'sufficient' when asked if the levels of lighting were sufficient [24] *Figure 9: Artificial lighting in one of the classrooms. Source [24]*
Noise		According to common responses when the evaluation team asked the students if they had any problems that disturb them in lessons, they complained about the classes next to each other and it is affect in their concentration [24] *Figure 10: Noise may occur from adjacent classes.*

Classroom arrangement	All classrooms in this school are arranged in the cluster form as shown below where students can sit together in groups and encourages interaction between students. *Figure 11: Cluster arrangement of classrooms' furniture.*
Furniture	This Factor is not mentioned in the case study; it can be deduced from the pictures that the classroom furniture is ergonomic for the students' dimension. *Figure 12: Classroom Furniture. Source [24]*
Colors	According to the teem observations, it was discovered that the color is not a significant issue that is taken into account within the design, but most of the staff knows the importance of colors of walls and the setting of furniture due to the huge impact of these elements on the learning attitude and performance of pupils. As shown in the figure below white, grey, and light colors are the most popular ones used in this school. *Figure 13: Classroom wall colors. Source [24]*

2.1.3. Case Study Evaluation

Below Table is a checklist showing the factors were obtained from the literature review and was used to evaluate the previous case study.

Table 1: Checklist of factors affecting the learning environment.

POE Factors		Existence	Evaluation				
School Environment Factors	Lighting	✓					
	Natural Sunlight	✓	●	●	●	●	●
	Artificial Light	✓	●	●	●	●	●
	Noise	✓					
	Nearby Classrooms	✓	●	●	●	●	
	Transportations Noise	N/A					
	Light Roof	N/A					
	Colour	✓					
	Light colour	✓	●	●	●	●	●
	Dark colour	N/A					
	Hue	N/A					
	Thermal comfort	✓					
	Temperature	✓	●	●			
	Humidity	N/A					
	Heating/Cooling Control	N/A					
Physical Environment Factors	Furniture	✓					
	Ergonomic	✓	●	●	●	●	●
	Classroom Layout	✓					
	Horse shoe	N/A					
	Rows/columns	N/A					
	Cluster	✓	●	●	●	●	●

2.2. Local case study: Fatima Anan Primary School

The case study was selected because of the following criteria:

- National public primary school
- Available access for walkthrough evaluation and questionnaire survey

2.2.1. Background Information

Fatima Anan is a public primary school located in New Cairo, Cairo.

2.2.2. Case study analysis

Classroom Environment		Analysis
Lighting	Natural daylighting	The windows of these classrooms are wide which allows the maximum sunlight inner the classroom. The figure below shows the windows in one of the classrooms. *Figure 14: Wide windows of classroom*

Artificial lighting		The figure below shows the artificial lighting in the classroom. The lamps are not distributed efficiently. *Figure 15: Artificial Lighting in classroom.*
Noise		The noise sources in the classroom are transportations noise and nearby cleanrooms. Some classrooms were Located on the main street while the other noise source came from the nearby classes as they are adjacent to each other. The figure below shows one of the classrooms located on the main street. *Figure 16: Classroom located on the main street.*
Classroom arrangement		Classrooms desks in this school were arranged either in rows/columns or Horseshoe layout. The following shows one arrangement from the school's classroom in row/columns layout. *Figure 17: Rows/Columns layout.*
Furniture		The furniture dimensions are appropriate for students' age and body.
Colors		The classrooms' wall painting is either pink or white. The figure below shows one of the classrooms was painted with pale pink. *Figure 18: Classroom wall painted with pink color.*

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2.3. Case Study Evaluation

Below Table is a checklist showing the factors were obtained from the literature review and was used to evaluate the previous case study.

Table 2: Checklist of factors affecting the learning environment. Source (Developed by Author, 2018)

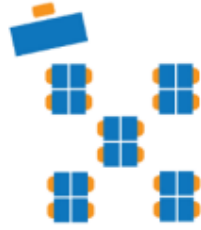| POE Factors		Existence	Evaluation				
School Environment Factors	Lighting	✓					
	Natural Sunlight	✓	•	•	•		
	Artificial Light	✓	•	•			
	Noise	✓					
	Nearby Classrooms	✓	•	•			
	Transportations Noise	✓	•	•	•	•	•
	Light Roof	N/A					
	Colour	✓					
	Light colour	✓	•				
	Dark colour	N/A					
	Hue	N/A					
	Thermal comfort	✓					
	Temperature	✓	•	•	•	•	•
	Humidity	N/A					
	Heating/Cooling Control	N/A					
Physical Environment Factors	Furniture	✓					
	Ergonomic	✓	•	•			
	Classroom Layout	✓					
	Horse shoe	✓	•	•			
	Rows/columns	✓	•	•	•	•	
	Cluster	N/A					

3. Results and Findings

This section is composed of analyzing the survey questionnaires and walk-through observation of the Fatima Anan Primary School in New Cairo, Cairo. The goal of survey questionnaires is to understand the user's perception and experience and increase the satisfaction and performance of students.

The students and teachers were chosen to contribute in the survey conducted. This aims at gaining as much data as possible about the users' needs. Two different manner forms of questionnaires were designed based on the factors that were obtained from the literature review to help create an effective learning environment.

Table 3: Post-occupancy evaluation factors whether kept or removed

POE Factors	Kept	Removed
1. Lighting	Natural Lighting	N/A
Added	Artificial lighting in the class must be distributed efficiently. *Figure 19: Efficient distribution of artificial lighting*	
2. Classroom Arrangement	N/A	Rows/columns
Added	Clusters arrangement should have been applied in classrooms. *Figure 20: Efficient distribution of classroom arrangement*	
3. Noise	N/A	Transportation noise and nearby noise
Added	Schools should be sited away from busy roads or neighborhoods. Sensitive spaces, such as classrooms can be carefully separated from noisy areas using buffer zones such as toilets, storerooms or corridors.	
4. Furnishing	N/A	Current desks and chairs
Added	Provide a creative shape and useful Design. *Figure 21: Example of creative shapes for studying desks*	
5. Color	Bright colors	Pale walls color
Added	Light walls with a feature wall highlighted in a brighter color contributes to an appropriate background level of stimulation. *Figure 22: Example of wall colors*	

4. CONCLUSION

According to the results obtained from the questionnaire surveys, and walkthrough observations, the following are the guidelines that should be followed to make sure that the performance of students is enhanced:

LIGHTING:

- Ensure the proper design of lighting in the school by allowing the most possible penetration of daylight in all classrooms and reducing the use of artificial lighting.

- This design should include a certain sequence of windows that are big enough to let the most possible light to enter, and should reach the height of desks used by students. Moreover, High-quality electrical lighting is essential to provide a natural light alternative.

INTERIOR ARRANGEMENT:

- The proper arrangement for primary schools is vital to allow the integration and interaction between students.

- Interior arrangement must be in a way that allows the students to work in groups and enhance the teamwork learning skills.

NOISE:

- Selection of site should be adequately done in schools in order to design the building away from any main roads or noisy activities.

- Offer a big green area that can divide these roads from the main building.

-The interior arrangement of classes must take into consideration dividing and separating classrooms to prevent any combination of sound and disturbance to other classes by using buffer zones such as toilets, storerooms or corridors.

COLOR:

- Design of schools should involve the use of multiple colors due to the huge influence on the learning attitude of children.

- Mixing more than one color is considered the optimum solution such as mixing light colors and hue in order to influence the learning of students.

FURNITURE:

- Those who are responsible on the design must make sure that the materials used for furniture in schools are in good condition and can provide the needed comfort for students.

- Provide a creative shape and useful design that will satisfy these students and increase their learning productivity.

CLASSROOM SHAPE:

- Should have individual distinctive design characteristics; for example, a distinctive shape (L shape; T shape).

This research focused on the interior design of primary schools and its influence on the learning attitude of the students. The main concentration was related to post-occupancy evaluation, which determines the general feedback of users regarding a certain issue in the field.

5. Recommendation

Finally, Future researchers need to study the other factors that affect the learning environment and need to focus on the other different learning stages. Future authors must take into account a procedure to experiment on the current design of schools by determining the natural lighting, and thermal comfort in schools. There should be an organization in charge of monitoring the design of primary schools in Egypt. One that recognizes the interior design of classrooms as an enhancing element of the learning behavior and students' performance.

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