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## FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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*Theme:*

## CURRENT TRENDS IN SCIENCE AND ENVIRONMENTAL MANAGEMENT

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# 1ST ANNUAL SCHOOL OF SCIENCE AND SCIENCE EDUCATION CONFERENCE

## FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

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## CURRENT TRENDS IN SCIENCE AND ENVRONMENTAL MANAGEMENT

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# ARCHITECT'S ROLE IN CONTROLLING ENVIRONMENTAL FACTORS AFFECTING EDUCATIONAL BUILDINGS

**O. K. Akande[1] and R. E. Olagunju[2]**

1. Architecture Programme, Abubakar Tafawa Balewa University, Bauchi, Nigeria
2. Department of Architecture, Federal University of Technology, Minna, Nigeria

**Abstract**

In many Nigerian schools, students and teachers find themselves in a physical environment that adversely affects their morale for learning and teaching and, in some cases their health. A well-designed school building with a conducive environment for learning can make a measurable difference in student's academic outcomes and teacher's motivation for teaching. Hence, it is essential for those involved in school planning and design to see the design of the school buildings as important as the design of the curriculum. This paper examined the role architectural design of school buildings and its environment plays in enhancing academic productivity of the learners. It highlighted environmental factors such as Indoor Air Quality, Ventilation, Landscaping, etc as they affect learning. It posited that when these factors are overlooked both in planning and designing of school buildings, they invariably have adverse effects on the student's academic performance. It recommended proper designing, construction and frequent maintenance of school buildings to create quality environment worthy of inspiring learning. It concluded that designing of buildings with inspiring environment will have positive effects on academic learning, but will require adequate funding, attention, competent design, and quality construction.

## Introduction

It has been established that people are influenced and affected by their environment. Hence the environment plays a significant role in the lives of people (Rivlin, 1985). Man is a living and active organism that can select, modify and react to his own surroundings. A close observation of what goes on in our immediate environment reveals that our experiences within the environment give rise to our emotions and beliefs, feelings, attitudes, judgements and values as well as our reasoning. Therefore, our immediate environment especially the one for learning should be properly managed in order to make it appealing, friendly, and inspiring for learning. A well designed school building with a conducive environment for learning can make a measurable difference in student's academic performance as well as teacher's motivation for teaching. On the other hand, when a school building is badly designed and in disrepair, student achievement will suffer (Linda, 1993). School authorities that often postpone repairs and delay construction of new facilities in order to save money during periods of financial austerity as well as making cuts in these areas are considered to cause more devastation than slashing academic calendars and programmes. Linda (1993), observed that in times of austerity when maintenance costs are often slashed first, the consequences of electing to defer maintenance will include premature building deterioration, indoor air problems, increased repair and replacement costs, and reduced operating efficiency of equipment. This invariably leads to the price tag for deferring maintenance to become quadrupled and the fallout of such decisions or negligence is that the condition of school facilities will be rapidly failing. The consequences of faulty school design, shabby construction and neglect of maintenance of existing buildings is what leads to an environment of peeling paint, crumbling plaster, non functioning toilets, poor lighting, inadequate ventilation and poor indoor air quality which affects the health and the morale of both staff and students.

According to Linda (1993), research indicates that the quality of air inside some public school facilities may significantly affect students' ability to concentrate. It is then unreasonable to expect positive results from students and teachers who daily learn and work in an adverse environment. Hence, schools that are under funded, and have low academic morale as well as dilapidated facilities will produce more dropouts and high rate of failures among its students. While a clean, quiet, safe, comfortable and environmentally friendly and inspiring school forms an important component of successful teaching and learning. Therefore, those involved in school planning and design should see this as an opportunity to enhance academic outcomes by creating better learning environment (Mark, 2002). The question then is what manner and degree are the environmental factors affecting academic outcome the most and in what manner and degree? This paper in finding answers to these questions examines these factors as highlighted below:

**Environmental Factors: It's Effect on Performance**

The environmental factors to be considered here will focus on both external and internal factors as they inhibit academic performance of students and motivation for teachers.

**Ventilation**

Ventilation as defined by Ogunsote (1991), is the replacement of used inside air by outside air with major function of supplying fresh air and body cooling. It is then obvious that in a sealed space, without the availability of fresh air from outside, the occupants of that space will die of asphyxiation. In many schools, a surprising number of classrooms lack adequate ventilation, and evidence is accumulating to support the common-sense notion that occupants of classrooms without good ventilation can't function normally and can't learn at their full capacity (Mark, 2002).

The purpose of providing adequate ventilation in classrooms and school buildings, at minimum, is to remove or otherwise dilute contaminants that can build up inside. Such contaminants come from people breathing, from their skin, clothes, perfumes, shampoos, deodorants etc and from a host of other agents that in sufficient concentrations are harmful. One of the first symptoms of poor ventilation in a building is a build up of carbon dioxide caused by human respiration.

When carbon dioxide levels reach 1000 parts per million (about three times what is normally found in the atmosphere), headaches, drowsiness and the inability to concentrate ensure. Myhrvold et al (1996) found that increased carbon dioxide levels in classrooms owing to poor ventilation decreased student performance on concentration tests and increased students' complaints of health problems as compared to classes with lower carbon dioxide levels. The major causes of these ventilation problems are due to poor architectural design, overcrowding and lack of provision or maintenance of air conditioning systems in the case of offices for the teachers.

Inadequate ventilation is often the cause of indoor air quality problems (Mark, 2002). Poor indoor air quality is widespread, and its effects are too important to ignore. Lack of indoor air quality causes physiological stress induced by excessive heat or cold that can impair functioning as well as cause injury or death. Exposure to intense heat increases body temperature and pulse rate. If body temperature is sufficiently high, sweating may cease, the skin may then become dry and deeper and faster breathing may follow.

Headaches, nausea, disorientation, fainting and unconsciousness also may occur. The initial symptom of cold stress is pain in exposed areas while continuous exposure may lead to numbness (inability to think well), mental confusion, lethargy and irregular heartbeat. Other consequences of poor indoor air quality is manifested in sleepiness, fatigue and dizziness which are often the main complain of students and teachers. This leads to making teachers and students sick-and sick students and teachers cannot perform as well and as much as healthy ones (Leach 1997).

**Landscaping**

This is the development and decorative planting of gardens, grounds, parks and other areas. It deals with the treatment of land areas not covered by buildings. When those areas are considered important to visual experience, landscaping of such areas will create for the people in the environment experiences that lift their spirit, expand their vision and invigorate their lives in an educational environment. Good landscape will enhance viewing, provide both mental relaxation and refreshment for the learner and the teacher, as well as create a delightful environment that positively affects student performance. The fragrance of flower and fruit around can produce scent that is delicate and subtle which covers unpleasant odours resulting from the pollution of air and foul smelling exhaust. Vegetation, water, and plants are known not only to improve physical comfort conditions but also help to produce mental stimulation and visual delight (Saini, 1980). These are paramount for mental productivity and empowerment needed for high academic performance.

**Thermal Comfort**

What constitute comfort? Macfarlane (1958) have defined comfort as certain thermal conditions in which over fifty percent of the people are unaware of their climatic environment – that is; they do not feel the need to adjust to it. Human thermal comfort is usually found when the mean skin temperature is maintained by various means below 93°F (33.9°C) and above 88°F (31.1°C). Researchers have been studying the temperature range associated with better learning for long. Harner (1974) found that the best temperature range for learning, reading and math is 68 - 74°F and that the ability to lean these subjects is adversely affected by temperatures above 74°F. As temperature and humidity increase, students report greater discomfort, and their achievement aid task performance deteriorate as attention spans decrease (King and Marans, 1979). Thermal factors may seriously degrade teachers' abilities to teach and may also affect their morale. Lackney (1999) showed that teachers believe thermal comfort affects both teaching quality and student achievement. Corcoran et al. (1988) focussed on how school facilities' physical conditions affect teacher morale and effectiveness. They conclude that problems caused by working conditions may result in higher absenteeism, reduced effort, lower effectiveness in the classroom, low morale, and reduced job satisfaction.

**Building Quality, Aesthetics and Maintenance**

McGuffay's (1982) synthesis of earlier studies correlated student achievement with better building quality, newer school buildings, better lighting, better thermal comfort and air quality, and more advanced laboratories and libraries. More recent reviews by Earthman and Lemasters (1998), report similar links between building quality and higher scores. Clearly, there is consensus that newer and better school buildings will contribute to higher student performance. But just how much varies depending on the study and subject area. In older buildings, a lack of maintenance can ruin an otherwise high-quality building; in new buildings, funding limitations can result in a brand new building of inferior quality.

Any careful study must account for these factors. Maxwell (1999) found a correlation between newer facilities and student performance levels and a significant relationship between upgraded facilities and higher mathematics scores. In one case, (Chan and Girrbach 1985) observed improved performance among students when buildings were renovated. For example, Lewis (2000) tried to identify the independent effects of school quality in a study of test scores from 139 schools in Milwaukee and found that good facilities had a major impact on learning. However, Stricherz (2000) notes that students performance lags in inadequate school buildings. Research does show that student performance lags in shabby school buildings – those with poor science labs and inadequate ventilation. Apart from student performance being affected, cracks on building, peeling paints and crumbling plasters gives unsightly appearance to the environment.

**Building Design and Construction**

This is a complex process involving the selection of standard building systems, and their adaptation and integration, to produce a building that meet the client's (user) needs. A well designed school building can elicit a sense of pride and ownership from its users. By investing in design excellence, schools are not just creating a quality building, they are creating a quality learning environment worthy of inspiring the users. Factors such as size, proportion, character and surroundings of rooms, the colour scheme, and even the views from windows have a great psychological effect (Saini, 1980). There is the combined effect of the sun, fresh air, and greenery which infringe on learners' (users') higher nervous activity, providing favourable sense impressions during periods of physical activity and rest. The proportions of the classroom also pose psychological significance to the learner.

Having considered some environmental factors within the educational environment that can be subtle to inhibit academic performance of students and job satisfaction of teachers, there is need to examine the role architects and architectural design will play in enhancing quality environment suitable for learning and teaching.

**Architect's Role and Design Solution**

The traditional role of the architect has been to design buildings that reflect the interests of the users. Without the interests, comfort, health and satisfaction of the user within the environment considered by the planner and the designer, the building and its environment may not be of any value to the users (i.e. the teachers and the students). Considerable research has however, shown that the attitudes, views and values of professionals are very different form those of the users they purport to serve. The difference between the professional designer and the user is more pronounced with unfamiliar user groups and unfamiliar building types (Appleyard, 1969). Borrowing a leaf from what a Dutch architect, Prak (1977) said, "the common sense of the architect is not the common sense of the user, simply because the one (i.e. architect) has been subjected to a professional training and the other (i.e. user) has not. Let us, therefore, mistrust the intuition of architects and try to find out where people's needs have been thwarted. This statement points to the fact that there is an additional role for the architect in understanding the needs of the people (users) and the environment he is designing for before embarking on his design. This understanding will help the architect in his building design to take into account the environmental factors that affects his users. This can be referred to as accountability in design which implies that the architect is accountable first and foremost

to people, user needs, and environmental factors. As architectural design carried out this way, may have its goal in the welfare and satisfaction of users of the buildings.

The application of environmental factor considerations in the design process will therefore require awareness, knowledge, and skill. The architect's responsibilities in designing environmentally suitable buildings will include a close cooperation and collaboration with educationists and educational administrators so as to know the impact his design will have on the educational outcomes of the users. Likewise, architects will also need to be aware of the quality required in the educational environment (i.e. environmental quality) as defined by the Organization for Economic Co-operation and Development (OECD). This according to Westbrook (1988) comprises three broad groups of factors or attributes: (a) health and safety factors (comfort, materials safety, building security, cleanliness); (b) environmental factors (heating, lighting, ventilation); and (c) curriculum related factors (program and support spaces, classroom adaptability).

## Architectural Design Solution

Architectural design plays a major role in enhancing academic productivity of learners and job satisfaction of teachers when they are taken into consideration from the design stage. This will result in high quality design of both external and internal educational environment. Therefore, in order to improve the performance of buildings in educational environment, a high quality building design should:

- Meet users needs and exceed their expectation
- Provide a positive environment and the activities that are accommodated
- Make a positive contribution to its immediate surroundings
- Help to promote a sense of community and social interaction
- Be economic in maintenance and running terms
- Be constructed with future needs or possible uses in mind
- Be environmentally appropriate and incorporate current best practice
- Provide value for money
- Be constructed in time and budget
- Establish a variety of outdoor learning environments

These can be achieved by considering the following:

### (a) Building/Classroom Design

To provide an acceptable environment without air conditioning in a building, a designer must be primarily concerned with controlling the micro-climate or the climate within the space enclosed by a structural shell. In practical terms, this means dealing with such environmental factors as temperature, humidity, rate of air movement, and radiation from walls, floors, ceilings, and other surrounding surfaces all of which have an effect on human comfort. When considered together and interpreted in design terms, these physical factors determine the performance of a building which in turns enhances the performance of the users. In considering the design of the classroom, Butin (2000) suggests four basic design principles

(i) Classrooms should be accessible to the outdoors to get the benefit of natural light, which increases students' alertness and decreases psychological stress.

(ii) They should be aesthetically pleasing in terms of colour, texture and patterns which increase students' sense of personal value and importance.

(iii) They should cluster around a commons, which increases students' sense of community and provides a sense of order, unity and cohesiveness

(iv) They should be adaptable and flexible, which increases students' concentration and learning by making both large and small spaces.

Goromosove (1968) added that the beauty, comfort, and design of a building and its surroundings can have profound scientific significance. Hence, measures adopted need to be analysed for their emotional significance and attention paid to auditory, olfactory, visual, and other stimuli factor that can influence both the way the person feels and his ability to work and learn.

Similarly, the proportion of habitable areas (classrooms) can also have psychological significance in building designs. For example, the height of the ceiling needs to be related to the floor area of the room. A classroom with a low ceiling appears to be larger than one of the same size with a higher ceiling, but the cramped space of the former can take away the feeling of relaxation and rest and could well exert an unfavourable psychological influence (Saini, 1980).

(b) **Planning and Design of External Spaces (Landscaping)**

The application of plants and water are known not only to improve physical comfort conditions but also help to produce mental stimulation and visual delight in the environment. Water can be used as a pool, as a falling stream and as a jet or fountain. Helped by sunlight and breeze, it is capable of creating a variety of moods. Pleasure in water can be described as pleasure in its multiplicity of face and mood, its elusiveness, its double talk of calm and commotion, surface and depth, illusion and reality, change and non-change. Essentially, water improves physical comfort by evaporative process, which by increasing the relative humidity, decreases the dry bulb temperature of the surrounding air. Water also has a value of cooling medium (Saini, 1980). On the other hand, intelligent and judicious use of vegetation, whether in the form of trees, shrubs and grasses or merely creepers and vines in learning environment, is known not only to help the micro-climate of a building but also to improve the visual qualities of the physical external environment. Researches by Deering (1953) indicate how plants and grasses reduce the heat load on exposed surfaces by obstructing the passage of solar radiation. Vegetation helps lower the surrounding air temperature by evaporative cooling as a result of transpiration. It also provides advantages as a wind break, thus arresting the flow of dust and sand into built-up areas. Trees in public spaces can serve as a substitute for bicycle, car, and bus shelters. If carefully planned and ordered in an educational environment, they can provide a pleasant foil against the flat and harsh building surfaces. All these qualities underline the importance of vegetation in providing an inspiring learning and teaching environment.

(c) **Paint and Colour**

The psychological effect of colour in both internal and external surface of building is well known. Various colour standards have been established which are based on ability to soothe, stimulate, cause visual fatigue, and/or promote increased learning and physical activities. For example, white and various shades of colours commonly found in nature, such as yellow and green, exert a soothing influence of the visual system by reducing eye fatigue and enhancing the strength of chromatic vision. Hence the importance of this fact can not be overlooked for a learning environment. Peeling of paints from the building in the environment occur when it is exposed to radiation, this result to flaking and scaling. One suggestion for achieving better performance of paints on building is to use paints based on alkyd resins, which are far superior to conventional oil paints in sunlight - exposed situations.

## Suggestions and Recommendations

Having discussed the factors that affects educational environment, it will be important to take them into considerations as neglect or overlooking them in planning and designing of school buildings will have adverse effect on the students' academic performance. The following suggestions and recommendations are made so as to create an effective learning environment either in planning for a new one or in upgrading existing facilities.

- **Consultation with Teachers and Other Users**
  Specialized consultants in education should normally be contacted before planning and designing school buildings and its environment to provide specific information about users group and educational needs through interviews and direct observation.
- **Enhance the Quality of the Environment**
  Educators and educational administrators should not only be concerned with securing more funds for the educational programs, but they should also strive to enhance excellent environment conditions that promote learning. A typical example is the transformation of Ahmadu Bello University, Zaria under the administration of Professor Mahdi, as the Vice Chancellor.
- **Maintenance of the Existing Structures**
  Whenever the need to restructure education is often discussed, there is often little or no mention of improving the physical site of learning. However, failure to repair and remodel educational facilities may offset benefits derived through restructuring the instructional program. This underscores the need to upgrade school facilities.

To create quality environment worthy of inspiring learning, there should be proper architectural design which should include

(i) proper building orientation, appropriate selection of building materials, carefully planned ventilation (i.e. by providing sufficient doors and windows which should not exceed the minimal size consistent with the need for good day lighting),adequate shading devices, provision of water fountain as an architectural element, proper selection of landscaping elements and quality construction technologies.

(ii) creation of spaces outside and adjacent to the building on site or on neighbouring sites that mirror learning space within the building to maximize the chance of year round use of parts of the outdoors, creating favourable microclimates by protecting outdoor activity areas from prevailing winds.

(iii) use of circulation to create gentle transitions from different spaces, taking advantage of turns and bends will also create unique areas of learning.

(iv) natural access control and natural surveillance. Natural access control uses doors, shrubs, and other physical design elements to discourage access to an area by all but its intended users. Natural surveillance is achieved by placing windows in locations that allow intended users to see or be seen, while ensuring that intruders will be observed as well.

## Conclusion

Schools, as organisations in general, cannot operate efficiently and effectively to attain the goals set up for them without appropriate attention given to quality environmental management. Though a properly design school building will result in better student performance, increased teacher satisfaction and retention, reduced operating costs, as well as have a positive influence on the environment, however, it will require adequate funding, attention and quality construction. Therefore, educators and most especially

educational administrators should give priority to providing and enhancing quality environment to inspire and motivate both the teachers and learners to work and learn.

**Reference**

Appleyard, D. (1969) "Why Buildings are known": A Predictive Tool for Architects and Planners. In Introduction to Architecture. Mc Graw-Hill, Book Company, U.S.A. pp 131-156

Butin,D.(2000)'Classrooms' National Clearing house for Educational Facilities. http://www.edfacilities.org

Claus, R.N. and Girrbach, C.J. (1985) An assessment Of the Saginaw Successful Schools Project. Paper presented at the Meeting of the Evaluation Research Society and the Evaluation Network, Toronto, Ontario, Canada, (ED264285)

Corcoran, T.B., Walker, L.J., and White, J.L. (1988) Working in Urban Schools. Washington D.C.: Institute for Educational Leadership (ED299356).

Deering, R.B. (1953) "Technology of the Cooling Effects of Tree and Shrubs". Building Research Advisory Board, Conference Report No, 5.National Research Council, Washington, D.C.

Earthman, G.I., and Lemasters, L. (1998) Where Children Learn: A discussion of how a facility affects learning. Paper presented at the Annual Meeting of Virginia Educational Facility Planners. Blacksburg, Va, (ED419368).

Goromosove, M. S. (1968) 'The Physiological Basis of Health Standards for Dwellings' Public health paper on.33, pp 77-86.World Health Organization, Geneva, Switzerland.

Harner, D.P. (1974) Effects of Thermal Environment on Learning Skills. The Educational Facility Planner 12 (2):4-6

King, J. and Marans, R.W. (1979) The Physical Environment and the Learning Process. Report number 320-ST2. Ann Arbor: University of Michigan, Architectural Research Laboratory (ED177739).

Lackney, J.A. (1999) Assessing School Facilities for Learning/Assessing. The Impact of the Physical Environment on the Educational Process, Mississippi State, Miss.: Educational Design Institute (ED441330).

Leach, K. (1997) In Sync with Nature: Designing a building with improved indoor air quality could pay off with improved student health and performance. School Planning and Management 36(4): 32-37

Lewis, M.(2000) Where Children Learn: Facilities Conditions and Student Test Performance in Milwaukee public school. Scottsdale. Ariz: Council of Educational Facilities Planners International.http://www.cefpi.org/pdf/issue12.pdf

Linda, M.F.(1993).Deteriorating School Facilities and Student Learning (ERIC Digest 82).

Mark, S.(2002)'Do School Facilities Affect Academic Outcomes? National Clearinghouse for Educational Facilities http://www.edfacilities.org

Maxwell, L.E. (1990) School Building Renovation and Student Performance: One district's experience, Scottsdale, Ariz.: Council of Educational Facility Planners International (ED443272).

McGuffey, C. (1982)' Facilities'. In improving educational standards and productivity: The research basis for policy, ed. H. Walberg. Berkeley, Calif.: McCutchan Pub. Corp.

Myhrvold, A.N., Olsen, E., and Lauridsen, O. (1996) Indoor environment in schools. Pupils' health and performance in regard to $CO_2$ Concentrations. In Indoor Air '96.

4. pp.369-71. The Seventh International Conference on Indoor Air Quality and Climate. International Academy of Indoor Air Sciences.

Ogunsote, O.O., (1991) 'Introduction to Building Climatology. 'A Basic Course for Architecture students. Ahamadu Bello University Press limited, Zaria . Nigeria p77

Park, N.L. (1977) The Visual Perception of the Built Environment (Delft: Delft University Press). p.90

Rivlin, L.G. and Wolfe, M. (1985) Institutional Settings in Children's lives. A Wiley Inter science Publication, New York.

Saini, B.S. (1980)."Building in Hot Climate" Published by Angus and Robertson Pty Ltd.pp28-31

Sincherz, M. (2000) Bricks and Mortar boards. Education Week 20(14): 30-32 http://www.edweek.org/ew/newstory.cfm?slug=14facilites.h20

Westbrook, K.C. (1998) Decision making in the Planning and Design of Illinois Public School Facilities. Paper presented at the Annual Meeting of the American Education Finance Association. Lubbock, TX, (ERIC report ED303913) Washington D.C. Department of Education, office of Educational Research and Improvement)