ENVIRONMENTAL COMFORT AND SCHOOL BUILDINGS: THE CASE OF CAMPINAS, SP, BRAZIL

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SUMMARY

This paper presents the results of an extensive Post Occupancy Study of 15 schools in the city of Campinas, SP, Brazil. The learning environments were analyzed as to environmental comfort conditions and possible simple solutions to improve the quality of the learning environment. Classrooms and recreation areas were observed and critical comfort conditions were measured with equipment. School directors, teachers, employees and students were questioned as to their perception and evaluation of the comfort conditions and given the opportunity to express their satisfaction and desires about their learning spaces.

KEY WORDS: School Buildings, Learning Environment, Post Occupancy Evaluation, Satisfaction and Desires, Intervention Possibilities.

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INTRODUCTION

This paper presents the results of a research project on school environments, conducted in the city of Campinas, Brazil. Many international and local studies exist which have evaluated the learning environment with different goals in mind. This study was undertaken to analyze comfort conditions of schools and develop ideas and simple solutions to common problems.

Many studies exist establishing a relationship between the physical comfort conditions in schools and the learning capacity of students (Gifford, 1997 and Yannas, 1995). Comfort conditions can affect attention span of students, speech comprehension and legibility of information presented. Spatial configurations and dimensions can inhibit the development of activities, deemed positive for learning. All aspects of comfort therefore play a role in the learning environment and should be optimized as to the spatial quality they provide.

In countries where codes on environmental comfort and building regulations are rigorous, schools generally reach an adequate standard of comfort conditions. In these countries research on the relation of environmental conditions and learning effectiveness concentrates on wider issues of environmental psychology. Specific details which contribute to the creation of a better total learning environment are tested, including the physical space, equipment, audio-visual material and human relations. Studies proceed in evaluating architectural configurations and the spatial conditions of classrooms. School size and grouping is analyzed. Furniture layout is related to attention span of students. Special in-depth studies are conducted on the effect of natural light or its absence. Urban noise interference with behavior in the classroom is analyzed (Gifford, 1997).

Other studies concentrate on defining, with more precision, important comfort parameters, such as internal classroom temperature, to improve learning performance. Research on energy efficiency is also seen as more and more important in relation to environmental education and the sustainable building questions arising (Gifford, 1997 and Yannas, 1995).

Some results of the relation between environmental comfort conditions and school performance, or increased learning by students, show architectural elements and detailing to be important. Evidence suggests that noise interferes with learning while it occurs and even after the noise is gone, in the case of long period exposure. Girls are more susceptible to noise than boys. When the task is more difficult noise interferes more with performance. Interference with information processing, lowering of perception of control and increases in blood pressure can be registered in noisy classrooms. Thus proper acoustic conditions are shown to be of extreme importance for adequate communication and to increase levels of learning by students. Behavior-modification techniques, as well, have shown, in many cases, to be important for control reinforcers in classrooms (Gifford, 1997).
The effect of illumination on student behavior and performance is less evident than in the case of acoustics. Since most research is conducted in adequately lit rooms, the influence of the type of lighting is not strong. But, as with noise, important effects of light may be on specific subgroups of individuals. Light conditions show, in overall results, to affect basic cognitive and motor activities. Thus a mixture of natural and artificial light, representing a large spectrum of light, should be the goal for classroom illumination conditions (Gifford, 1997).

Space density and furniture arrangements are extremely important for classroom performance and related behavior. Choices of activities are curtailed in overcrowded classrooms, thus reducing the students learning experience. Increased social density has been shown to lead to higher aggression and withdrawal. Classroom performance is however always strongly related to teaching styles and methods and age grouping. These factors and architectural features, such as the open classroom, may counteract a high density factor (Gifford, 1997).

In sum, school architecture has a variety of influences on students. Having an attractive school is associated with better classroom performance. The school size issue must always be carefully considered. Students in large schools have more opportunities, but often learn as spectators and not as participants, prevalent in small schools.

Research on the school environment in Brazil is mainly concentrated on minimum comfort and maintenance conditions. Thus, we find that in the public school system in the State of São Paulo, few schools adopt innovative teaching arrangements. Traditional classrooms for 35 to 40 students prevail, with small individual desks in rows. Most studies show that comfort conditions are below standards for all comfort aspects (thermal, acoustics, lighting and functional details). Thus classrooms are shown to be overcrowded, hot in summer and without uniform illumination levels. Glare problems are common. Communication suffers from high reverberation levels and outside noise interference (Kowaltowski et al., 2001 and Ornstein and Borelli, 1995). Since schools are mostly built for a smaller total student population than the actual students present, many adaptations are made in school buildings, often without technical advice.

On the national level, a recent study showed that 13% of the population considers school buildings to have serious problems and that the lack of school books and equipment contributes to a low standard of education in the country (INEP/MEC, 2000). The same study pointed out that school building defects are related to: leaking roofs, badly finished walls and floors, lacking or broken doors and windows and especially to the precarious state of bathroom installations. These conditions get worse in locations in the northeast of the country.

When analyzing the history of school architecture in Brazil and particularly in the State of São Paulo, one can recognize periods of monumental buildings intended for the education of the local
elite. Today school buildings are regulated by a State Foundations (FDE, 1990) and school designs must follow standard rules and regulations. Although this situation would imply a minimum construction standard, this paper presents data from a recent POE (Post Occupation Evaluation) and user satisfaction study showing that many schools still fall short of offering comfortable conditions and thus can be said to interfere with the classroom performance of its users.

METHODODOLOGY

The methodology used, to collect data on the comfort conditions of school buildings in the Campinas (SP, Brazil) region, was based on POE methods of observation, application of questionnaires to users and technical tests and measurements of comfort parameters. To evaluate the school environment in the public school system of the city of Campinas, 15 school buildings of the 150 State Schools in the region were evaluated.

The sample definition was based on random selection of a structured total of school buildings in the region. The sample structure took into account age grouping of pupils in each of the 150 schools. 43 spaces (classrooms and recreational spaces) were observed, measured and tested at three distinct times (8h00, 12h00 e 16h00). Questionnaires were applied to 15 directors, 48 staff, 56 teachers, 1414 students with reading and writing abilities and 358 first grade students. Comfort satisfaction and desires for the school environment were assessed. For first grade students the questionnaire used drawings representing the various satisfaction levels for each question. Open questions were answered through drawings as well by the children.

Environmental comfort conditions were assessed through technical measurements. Functional aspects of the classroom were observed. User behavior, type and arrangement of furniture and equipment, occupation density and dimensions of rooms were registered. This data led to the technical evaluation of the visibility of the blackboard in each room, the ergonomic adequacy of furniture and equipment in relation to user age groups and the general level of organization of classrooms in relation to observed activities.

Buildings were observed to assess the quality of construction techniques. Building materials and construction types were observed. Maintenance conditions were evaluated, especially in relation to bathrooms, storage and cleaning facilities. Fire safety and security details were tested. The neighborhood was characterized and urban infrastructure was evaluated.

Comfort parameters in relation to illumination and visual communication in the classroom were observed and measured. Light levels (lux) were taken in various points in the room. Glare was recorded in relation to desk tops and blackboard surface area. Observations were made in relation to the existence and position of curtains and external sun protectors.
Thermal comfort parameters were recorded through temperature (dry, wet bulb and radiant) and air speed measurements. Shading devices were once more observed and their position. Ventilation conditions were analyzed. The presence of mildew was registered.

Verbal communication was assessed through acoustic parameters. The conditions of open or closed windows or doors were recorded. Equipment noise, such as ceiling fans, was registered. Noise levels were measured. The origin of outside audible disturbances was analyzed. Thus school activities or neighborhood problems were distinguished.

Data was collected and structured into a data bank. With this system cross referencing is possible and simple solutions to improve comfort conditions can be devised through data analysis. A school improvement and maintenance system was developed to allow staff direct access to information on specific spaces in individual schools or general data on the most common problems and their solution options (FACCIN ET AL. 2001).

**SCHOOL COMFORT CONDITIONS**

All of the 15 school buildings were found to have comfort problems. Most buildings showed that schools lack sufficient financial support, which is most apparent in the maintenance conditions of buildings. Many schools have insufficient numbers of classrooms, no library or special rooms for laboratories or audiovisual equipment. There is a serious lack of storage space, apparent in improvised deposit solutions under stairs and in the back of corridors and even classrooms.

A comparison between the school buildings and their architectural programs shows, that the programs were insufficiently dimensioned and lacked detailing. Programs did not take into account growing demands on school buildings and the changing concepts of teaching in general. Therefore, all schools were found to be based on the repetition of standard sized (7m x 7m) classrooms.

To accompany the dynamics of today’s educational systems, school buildings need complex restructuring and in most cases more functional space. These modifications and additions should have technical support at the design and execution stages. The results of this study point out some major deficiencies. The study thus has the intention of orienting school principals in the task of improving the teaching environment in their individual schools through incremental progression.

When analyzing the comfort conditions in detail, thermal comfort is shown to be a major problem. Most classrooms are facing east and have serious problems with direct sun penetration. This causes over-heating and thermal discomfort during most of the year. A lack of adequate ventilation for summer climate conditions was also observed and measured in most schools. Since winters are mild in the region, the only serious problem was that of lack of wind control in the covered recreational areas, which are used for the lunch break by the children. Although the thermal conditions are not
ideal, some simple solutions can be suggested. First and foremost, windows should have sun protection in the form of external shading devices. Cross ventilation must be made possible through open doors or the introduction of additional openings in all classrooms, after acoustic interference is assessed. User participation in improving comfort conditions must be stimulated. Windows and curtains were found to be closed in many classrooms in overheated situations. The participation of students was stimulated by the study itself, which, to the research team, was a promising sign of the possible introduction of improvements. Students became aware of the environment and with increased perception were ready to intervene.

Illumination levels in most classrooms were under the recommended light levels of local standards. These light levels were often due to dark surface colors, closed window curtains and high lot walls in close proximity to windows. In some cases large vegetation was observed to interfere with natural illumination from windows. Visual problems such as blackboard and writing surface glare were observed in the majority of classrooms. These problems are basically related to orientation of classroom windows and improper shading conditions. Simple solutions include installation of external shading devices, painting of interior surfaces with light reflecting colors and improvements of the artificial lighting installations. Energy efficient fixtures should be evenly distributed over ceilings to ensure uniform light levels. In relation to the interaction of people with their physical surroundings, again, observation data shows the importance of environmental awareness. Participation of users, acting upon uncomfortable conditions, is of importance to attain a minimum level of comfort. Regulating light levels and eliminating glare through manipulation of curtains is a simple improvement measure.

All classrooms had serious acoustic problems, with high noise reverberation and speech recognition problems. In some cases urban traffic noise was a problem in individual rooms. Interference of varying school activities, as well, was frequently observed. Finding solutions for acoustic problems is no simple matter. Since all buildings depend on natural ventilation for summer thermal comfort, windows and doors cannot be closed. In most cases, building renovation is necessary. Installation of acoustic material on ceilings to reduce noise reverberation can be considered a minimum improvement measure. The study results show that the main problems stem from noisy activities of users, such as rehearsals of dances and sports activities. Classroom discipline problems cause shouting and furniture moving disturbances. Behavior changes are thus seen as an important means of creating improved acoustic conditions for educational activities. The school administration, as well, can act on changes in activity schedules, preventing noisy activities to take place near classrooms with quiet work tasks.
All schools had overcrowding and in some cases lack of appropriate furniture for age grouping. Equipment distribution was poor. Bathroom facilities in all schools were also found to be underdimensioned. Overcrowding limits the variety of activities able to take place in classrooms and restricts movement of users. These conditions hinder the full working life of a school, limiting important educational experiences for children. In relation to these functional problems of buildings, simple solutions are more difficult to be established. Problems are mainly related to a lack of space. Additions are necessary. Where schools tried to improve conditions, the additions or adaptations were piecemeal solutions, often causing new interference problems. The case of the school (EEP Armelinda da Silva) in Figure 1 can be used as an example. The school expanded through additions of wings as shown in Figure 1 ‘A’. However the additions always interfered with existing constructions. The roof was extended to create new access corridors and classrooms impairing lighting and ventilation conditions. Simple changes as shown in Figure 1 ‘B’ can minimize the effect of the additions. The inversion of one of the classroom wings and the removal of the central corridor are sufficient to give natural light and ventilation to all classrooms. Classrooms in this school face east and west and appropriate shading must be provided.

“Please, place figure 1 here”.

SATISFACTION AND DESIRES

Despite the less than ideal comfort conditions, user satisfaction was found to be high. Problem perception is low and desires are often unrelated to the learning environment. Most students show major interests only in recreational facilities and activities not related to the school environment. When expressing their desires for improving the school environment, first grade children mainly expressed interest for items related to friendship and social and recreational activities as shown in Figure 2 ‘A’ – ‘C’. Some children demonstrated strong influences of family values, by desiring a chapel or church in the public school as seen in Figure 2 ‘D’. Few students are aware of comfort detailing of classrooms. Desires of more learning material and equipment, even showing a ceiling fan, were expressed in rare cases (Figure 2 ‘E’ and ‘F’).

“Please, place figure 2 here”.

The open questions on the preferred place in the school and on desires showed that the group spirit is the major force in expression. Thus with younger children the classroom is a major force. If one of the children expressed interest in the playing field, the majority of students in that group followed suite. Momentary desires are also strong in younger children and often context unrelated. Thus many first grade students showed in the drawings desires for items that are in fashion, unrelated to the school environment.
An overall analysis, of the open questions on satisfaction and desires, pointed out that most perceived problems are not related to the physical environment. Administrative and discipline issues, as well as the general spirit present in the user group, are reflected in the answers. Thus personal relations and social activities play a major role in user evaluations of the school environment. When looking for specific physical aspects in satisfaction or problem expression, users are more aware of cleanliness or maintenance problems than serious environmental comfort issues. A tentative conclusion can be made. The actual non-ideal conditions diminish expectations and reduce the desire for a richer and more comfortable classroom setting.

School staff and teachers, in contrast to students, are more aware of comfort problems. The causes of uncomfortable conditions are however not always identified. Thus these users are unaware of the overheating of classrooms by direct solar radiation. Curtains are drawn for reasons of glare and seldom to improve thermal conditions. Teachers are aware of the fact that they raise their voices for classroom communication. Resulting stress is attributed to discipline problems, not high noise reverberation conditions. The direction of schools has good intentions to improve the physical conditions of schools through spatial adaptations and piecemeal renovations. The unsatisfactory results are not linked to such interventions without planning, design and technical support.

**CONCLUSION**

This paper presents, in part, the results of a comprehensive study of comfort conditions in 15 State Schools in the city of Campinas, Brazil. Users were involved in the study to express their satisfaction, perception and desires in relation to the school environment. The study contributed with important data collection on local learning conditions, and the need for improvement. The quantity of data collected was a stimulus to create an information system for design data for local school buildings. Thus the research data was organized specifically for local schools to guide their school building improvement plans. The study also stimulated the development of teaching material to increase user environmental awareness. The presence of the research team in the schools showed an increase in environmental perception by all users. The importance of user interaction with the environment was evident in comfort observations. Users can improve their conditions through simple interventions, such as increasing ventilation conditions by creating cross-ventilation.

The conclusion that can be brought forward is that a well functioning space, be it for work or learning, depends not only on the quality of its architecture, which supports the activity, but on the interaction of other factors. Thus the adequate disposition of equipment and furniture is important. Awareness and cooperation of users, to act on adjustments of specific situations, are essential elements to respond to the dynamics of actual space use. Participation is thus essential to create correct settings for momentary and specific activities.
To stimulate participation and increase awareness in schools the teaching of environmental comfort concepts is recommended. More research is considered necessary to analyze user participation in depth. Preliminary findings indicate that every user group has a so called leader (BERNARDI, 2001). These individuals seem to have a sharper perception of environmental conditions and initiate participation, other acts of intervention follow, stimulated by the example and peer pressure, present especially in the school environment. Investigations must detect the influence architectural elements can have on these leaders. The question arises, if specific configuration and details can increase perception. Studies on the relationship of people and specific learning environments are thus being developed as they apply to local school building conditions.

REFERENCES


Figure 1. ‘A’: Plan of the Armelinda da Silva School in its present conditions and ‘B’: Proposal of corridor inversion to improve environmental comfort conditions.
Figure 2. School children’s desires expressed in drawings.