Local and Global Modern Thinking. Designing with Climate in Mozambique: School Buildings Production

By Zara Ferreira[1]

The novelty of modern architecture in the former Portuguese African colonies derives from the fact that the ideology of the Modern Movement was interpreted locally. This built heritage is represented in terms of its responsiveness to the physical environment in which it operates, by means of *Design with Climate–A Bioclimatic Approach to Architectural Regionalism* (Olgyay, 1963). Combining tradition and innovation, this approach sought to address the specific socio–cultural context within which modern architecture was conceived (Kultermann, 1969).

With the purpose of contributing to the documentation and conservation of modern heritage in Africa, interpreted in the light of these assumptions (Quintã, 2007), this paper addresses a particular architectural program–school buildings–widely developed and built in Mozambique, between 1955 and 1975, the year of independence for the former Portuguese colonies. Initially led by architect Fernando Mesquita, as part of the Public Works Services of the Province of Mozambique, it was reconfigured and evolved through various levels of education, ranging from primary to high schools. Extensively built in urban and rural territory, and even gathering later contributions from other authors,[2] the built output of this program remains a prominent feature in the Mozambican territory.

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It's no accident that the most significant architectural achievements in Africa are to be found among educational buildings. The basic schooling of the African–as well as the education of his teachers–ranks before all economic, political, military, and other considerations. Elementary and technical schools, teacher's colleges, and universities are thus the primary tasks of building in the new nations.

Udo Kultermann, 1969

Modern Movement architecture in former African Portuguese colonies, namely in Mozambique, was developed within the scope of African investment overseas conducted by the *Estado Novo* dictatorship (1926–1974). According to updated UNESCO policies (1951), the educational program was a main focus of investment initiatives, following the strategies of other African countries (Raedt, 2012).

Although high school buildings were initially designed in the metropolis (Lisbon) by professionals connected to the Board of Construction for Technical and Secondary Education (1934–1969)[3] or later by the Ultramarine Urbanization Office[4] (Tostões; Bonito, 2012), the role would soon shift to local offices. At the same time, two phenomena were of particular consequence: the wave of Portuguese architects' emigration to African colonies after World War II and the increasing autonomy of these territories (Tostões; Oliveira, 2010). In Mozambique, it gave rise to the development of the Public Works Department (Ferreira, 2008), where a school trailblazer concept was developed by Fernando Mesquita.[5] Seeking for comfort in a tropical climate, a *modus operandi* was conceived and applied (Ferreira, 2012), varying according to the climate of each site. Establishing a methodological brand, an efficient and technical approach was achieved connecting design tools with sanitarian requirements.

1. Thinking Global

The Fernando Mesquita concept arose from the need to construct educational buildings on a large scale and in a short period of time, throughout the whole of Mozambique and for several education levels. Emphasis was placed on fast execution at minimum cost. However, the education program in Mozambique was still in the process of being defined. Given the uncertainty of the program and of the school population, one of the key design requirements was "to ensure the school has the greatest possible flexibility in future use, alteration, extension or adaptation, in order to reduce the risk of obsolescence" (Mesquita, 1961).

Therefore, depending on age level and type of education, the concept was developed electing the class-

room as the basic unit of spatial organization. More or less square in plan, the classroom is designed in a single compartment, always with at least 2 sides in contact with the outside, and flanked by a covered circulation gallery on 1 side. Initially designed for primary schools, based on the continued aggregation of rooms side by side, this model was later evolved in professional and secondary schools (technical, preparatory, commercial, industrial and high schools). Here, the basic unit of spatial organization is the grouping of classrooms, referred to as pavilions. These are distributed perpendicularly along a main covered circulation gallery. In some cases, the schools acquired 2 main circulation galleries, structured on a grid of orthogonal circulation, such as the Lourenço Marques Technical Elementary School (nowadays *Estrela Vermelha* High School) built in Maputo in 1961.

Acting as a backbone, the main gallery is assumed as the principal circulation channel, perpendicularly linked to the secondary access galleries, which give access to all the pavilions. With strict rationality and functionality, this system allows an economy of paths while ensuring shelter from the elements.[6]

In terms of functional organization, schools are divided between the school sector–aimed for teaching activities–the administrative sector and communal spaces. In the 60s, the sports sector also assumes a major role in high schools, with an independent pavilion for physical education. The school sector always assumes the major role. In primary schools, it is composed of a single floor of classrooms. In the professional and secondary schools, it is divided between classrooms–usually in 2 or 3 two-storey pavilions–and experimental teaching classrooms (workshops, crafts, design, etc.)–in 2 or 3 one-storey pavilions of more generous dimensions. The Portuguese Youth had as well a pavilion of its own, with the gym, such as the canteen and the choral, usually located in small spaces at the end of the main circulation gallery. In these schools, the administrative sector also acquires an independent pavilion, always adjacent to the school entrance. A backbone along which the programmatic blocks are judiciously articulated, Fernando Mesquita's system constitutes an archetype adaptable to different contexts. Almost based on a logic of mass production, his model projects were able to respond quickly and efficiently to the shortage of school buildings in the whole country.[7] However, no two similar designs can be found in Mesquita's legacy of school buildings: he was beyond the simplistic logic that a model project could hide.

2. Thinking Local: Design with Climate

The climate of most of the case study sites–Maputo, Inhambane, Beira, Chimoio (former Vila Pery), Quelimane, Nampula, Pemba (former Porto Amélia) and Nacala–is characterized by average high temperatures of 22ºC in the hot season, combined with torrential rains bringing about high levels of moisture in the air. The main challenges for architectural design in tropical and subtropical regions lie in the optimization of solar gains and rain protection, while ensuring maximum ventilation to counter the effects of humidity.

To assure a positive environmental performance in these schools, the classroom was conceived as a single compartment between two opposing façades with a strong relationship with the exterior. What immediately caught the attention of

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Figures 1, 2. Primary School of Quelimane. Photo by Catarina Delgado, 2012.

Figure 3. **João José Tinoco** and **José Forjaz**, Polana High School, Maputo, 1969–1973. Photo by Ana Tostões, 2012.

Figure 4. Quelimane Technical School, 1960. Photo by Ana Tostões, 2012

Figure 5. Nampula High School, 1969. Photo by Ana Tostões, 2010.

Figure 6. Nampula Technical School, 1953–1973. Photo by Ana Tostões, 2012.

Figure 7. Nampula High School, 1953–1973. Photo by Ana Tostões, 2012.

Figures 8, 9. Quelimane High School, 1969. Photo by Ana Tostões, 2012.

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Prof. Ana Tostões and Maria Manuel Oliveira during their missions to Mozambique (2010 and 2012), was the detached and non aligned implantation of these structures in the urban context, suggestive of the importance of climatic considerations in the design. The buildings' implantation with respect to solar paths and wind directions would become the most representative principle of Mesquita's design with climate.

Sun Exposure: Protection Conditions and Lighting

Regarding sun exposure, the main challenge is reconciling the need for adequate shading, while ensuring an appropriate quantity and quality of light in spaces, depending on their function.

Building orientation is the main strategy: by means of longitudinal deployment, the façades that could develop further would be positioned along an east-west axis, protecting the 2 larger walls from the sun. This orientation is adopted in most of Mesquita's schools; exceptionally they are geared towards the east, since the morning sun is less harmful.

Subsequently, it becomes imperative to protect the north façades from sun exposure that remains vertical the main part of the day and year. The aforementioned galleries and roofs of the pavilions, when located on the north façade, fulfill this role efficiently, articulating the circulatory function with horizontal shading devices.

On the south façades, where sunbeams are more horizontal and only perceptible at the beginning and end of some days, the openings tend to acquire large dimensions and are protected by vertical shading devices to prevent the sun from reaching the interior spaces on the hottest days. For this purpose, Fernando Mesquita employs the vertical *brise soleil* conceived as a continuous element of the structure. Both shading devices are external, intercepting solar radiation before it reaches the façade and preventing the overheating of construction materials. Furthermore, as they derive directly from the construction elements, they present fewer maintenance problems.

The combination of these shading devices with the orientation strategy was crucial in obtaining correct classroom lighting. With larger windows on the south façades and the circulation galleries to the north, a uniform and diffuse lighting is achieved inside the classrooms, further enhanced by *beta* windows. These consist of horizontal glass strips about 10 cm wide, mounted on a thin and almost invisible iron structure (Caldas, 2011) that functions as an adjustable shutter "allowing control of the quantity and direction of both direct and diffuse light" (Mesquita, 1961), without hindering the thermal comfort nor visibility towards the exterior.

Outside, the presence of vegetation is constant, playing a major role in the process of air and floor cooling as well as providing further shade. It also helps filter pollution, dust, noise and visibility from the outside.

Air Moving: Conditions of Aeration, Ventilation and Protection from Rain

Known as "the climate for mushrooms"[8] (Castro Rodrigues, 2012) it is commonly accepted that the main disturbance to human comfort in these climates is humidity. The renewal of air by natural

ventilation thus plays a vital role in countering the negative effects of humidity.

For ventilation to be effective, the air streams have to pass through the entire interior in an efficient way, cooling the surfaces and the users. To assure the best performance, it is necessary to promote the "easy incidence of winds, frequent during the hot season" (Mesquita, 1961). In these matters, the building implantation proved to be, once more, of upmost importance: most schools are orientated in such a way as to allow the prevailing winds in the warm season to reach the façades perpendicularly, where the larger windows are located. This brings about cross-ventilation in the classrooms as well as rainwater protection, since the larger openings are located on the opposite façade where the circulation gallery stands.

However, before the air reaches the interior spaces, its behavior is defined by interactions between elements in the surrounding built environment. While schools, built on unimpeded plots, benefit from fluid air circulation, one of the classroom pavilions does not have optimal conditions as it is shaded by the preceding pavilion. This situation is nonetheless well settled in other single floor pavilions, where the slope of the roof allows the routing of air consecutively to all pavilions. The larger windows facing the direction of prevailing winds, found in almost all schools, ensure air circulation. To favor the circulation, inlet openings are almost always larger than the outlet. This improves the conditions of the disadvantaged classroom pavilion mentioned above, assuring air renewal even in periods of absolute calm. The *beta* windows can assure a "permanent ventilation of the classroom even in rainy conditions and simultaneously control the direction and the speed of the wind" (Rute Bota, 1971).

The Implantation: "a Compromise Solution"?[9]

If in all the cases the two basic factors influencing architectural creation in tropical regions–the sun and the winds–could be harmonized by means of a perfect implantation, all the aforementioned passive systems would work. This is however not always the case. The compromise situation between over-heating and permanent air circulation, gives rise to the two distinct approaches in the implementation of Fernando Mesquita's schools. The Nampula and Quelimane schools can be considered the prototypes of the respective approaches.

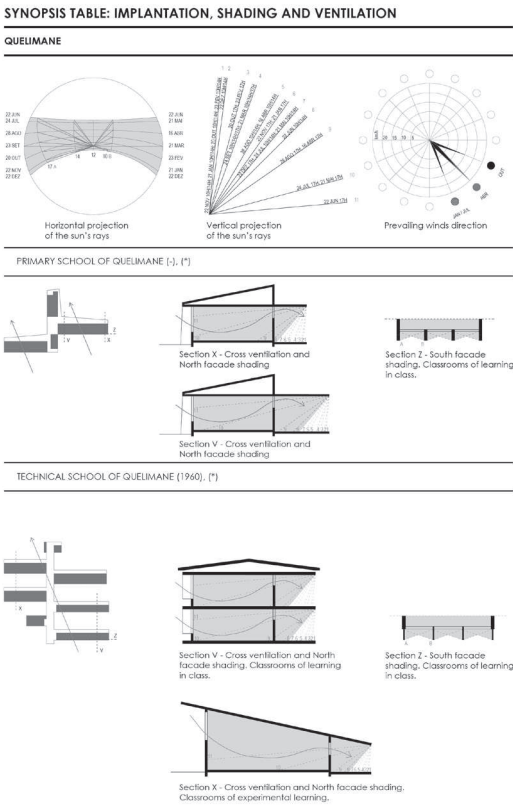
In the Quelimane schools, air circulation and sun protection are perfectly articulated, while in the Nampula schools only the air flow performs its role rigorously. The perilous situation in terms of sun protection in the Nampula schools suggests that the Fernando Mesquita concept has been developed for situations where the winds come from the South. Otherwise, the option has been to turn the model 180º, without making any adjustments to the new situation in terms of sun protection, since horizontal shading devices are of no use on façades facing south and vertical ones are of no use in the north façades; exchanging devices, we observe excessive brightness in the interior spaces causing visual discomfort and over-heating.

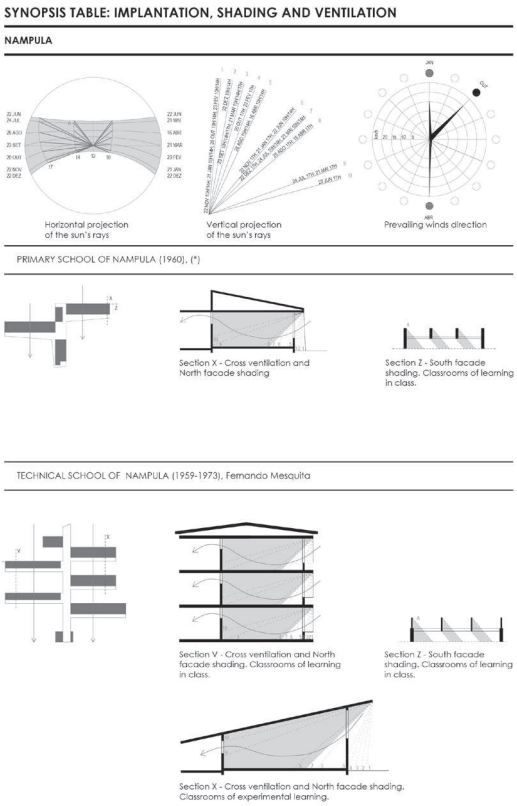
Several studies have indicated that in hot and humid climates, ventilation should be a design priority to the detriment of the ideal sun protection. Considering that it is the only means of combating the discomfort caused by excessive humidity, the need for adequate ventilation is of particular importance in classrooms given their high occupancy rate.

Furthermore, air circulation helps to prevent potentially fatal (Fry, Drew, 1964) insect bites, responsible for diseases such as malaria.

3. New Directions[10] Towards the Future

Reflecting confidence in the virtues of modern architecture, Fernando Mesquita developed an architectural blueprint or rather a *modus operandi* for designing in the tropics, with the purpose of ad-





dressing the shortage of school buildings in Mozambique between 1955 and 1975.

In terms of construction, the fusion between a functional and a modern material solution is evident, based on the use of exposed reinforced concrete–"giving the building a character of truth that all correct solutions require" (Mesquita, 1961)–and the use of prefabricated systems, local materials and techniques (with consideration for reuse). Both choices are well suited to the conditions that the structure and material are subjected to: high degrees and variations of temperature, moisture and precipitation, combined with acoustic and mechanical concerns implicit in a school programme. "In all the matters, I always looked for the most efficient solution, recommending only materials and construction processes of great durability; in each case, I looked for solutions as lasting as the circumstances could allow, avoiding the mistake of exaggeratedly economizing on resources that would lead to excessive conservation charges, that would reduce efficiecy and eventually the life span of the building" (Mesquita, 1961).

After more than 50 years of intensive use, exposed to severe climatic conditions and intensively used, these buildings have proven to be of immense strength, mainly reflected in the efficacy of their device systems and exemplary structural resistance.

Based on its capacity to provide better and more comfortable living conditions (Tostões; Oliveira, 2012), Fernando Mesquita's school building programe articulates a just reconciliation between the modern and the local. Intrinsically democratic and designed to respond to the comfort index of tropical climates and cultures, his architecture has been appropriated by local population in a way that proves its propensity to respond to the socio cultural and environmental requirements of these territories. Notably, his solutions continue to be adapted today.

At a time when this heritage is reaching the end of its lifecycle and the economic and demographic development is threatening its destruction, the definition of intervention strategies becomes a priority. Through the development of know-how in rehabilitation, we could contribute to the maintenance and improvement of the intrinsic qualities of these buildings, in turn enhancing the experience of their users. The school, as a support structure of one of the most important social resources–education–should be a priority intervention target.

From the technical detail to the functional typology update, the creation of an intervention plan could make the survival of this modern heritage possible. Fernando Mesquita's school buildings proved to be cost-effective and flexible, able to adapt to contemporary needs, both in physical, environmental and social means. In addition to the social mission that was intrinsic in the genesis of modern architecture, the Modern Movement has always aspired to economy and the efficient use of resources; its main mission always having been to build a better world (Tostões, 2011). Whence it would be partinent to develop a research project that looks to the reuse of these structures in a sustainable manner, based on a dignified management of resources.

Notes

1. Zara Ferreira is an intern architect and research fellow at the Department of Civil Engineering and Architecture at Instituto Superior Tecnico. This research has been developed under her architecture master's thesis, "O Moderno e o Clima na África Lusófona. Arquitectura Escolar em Moçambique: o Programa de Fernando Mesquita" (1955-1975), Lisbon, IST-UTL, 2012. Supervised by Prof. Ana Tostões (IST-UTL) and Maria Manuel Oliveira (EA-UM), under the research project (PTDC/AUR-AQI/103229/2008) EWV-Exchanging Worlds Visions, developed by IST-UM.
2. Polana High School (1969-1973), Maputo, by João José Tinoco (1924-1983) and José Forjaz (1936-).
3. Salazar High School (1945-1952), current Josina Machel Secondary School, Maputo, by José Costa e Silva (1911).
4. Based in Lisbon, supported by a framework of architects and engineers, the goal was to concentrate on a single public entity the design of all architecture projects and urban plans supported by the State for African colonies. It took an active part in the initial school production developed in Mozambique. Although it had an intensive production (1956), it didn't last long and had no continuity with the school designs developed in the following years. Assuming a modus operandi, this production consisted on a few model projects based on the "Normas para as Instalações dos Liceus e Escolas do Ensino Profissional nas Províncias Ultramarinas", 1956. Led by a team of 3 architects: Fernando Schiappa (1926), Lucínio Cruz (1914-1999) and Eurico Lopes Pinto (1914-?), the set of constructions varies between 2 fundamentally distinct types, whether it was intended to be constructed in Angola and Mozambique: one for high schools: Pêro de Anaia High School, Beira; António Enes High School, Maputo; D. Guiomar de Lencastre High School, Luanda (1956); and another one for Technical Schools: Inhambane Elementary Technical School, Nampula Elementary Technical School, Silva Porto Elementary Technical School (1956).
5. Fernando Ferreira Botelho Queiroz de Mesquita, (1916, Vila Real) obtained his architecture diploma in 1944 in Oporto and attended urbanism classes at London University. He went to Maputo, at the end of the 40s, where he worked as an architect and urbanist and was in charge of several Public Works offices and directed the Urbanization Office of Lourenço Marques City Council, created in 1964. Advocate of the Modern Movement principles. Fernando Mesquita was responsible for many of the public and private orders received by young architects who were working in Maputo at the time: Fernando Eurico, João José Tinoco (1924-1983), Maria Carlota Quintanilha (1923-), Marcos Miranda Guedes (1924-2001), Alberto Soeiro (1926-1968), Craveiro Lopes (1921-1972) and Pancho Guedes (1925-). He stayed in Mozambique after its independence, dying in Maputo in the 90s.
6. "The gallery as a typological element, is related with two fundamental factors: the spatial organization, regarding the access distribution and circulation, and the qualification of a space that is both inside (because it is framed into the limits of the building and, being covered, it is protected by the sun and the rain) and exterior (because, exposed to the air circulation, it is in contact with the outside temperature and noise)" (Magalhães, 2009).
7. It was possible to study 35 case studies, built along only 2 decades; by mapping the territory with Google Earth software it was possible to identify 20 more cases.
8. Francisco Castro Rodrigues (1920, Lisbon) in a personal interview (03.04.2012), uses the word "mushroom" as an analogy to the lichen, a common type of eczema in the inhabitants of these climates, caused by the combination of high temperatures with high air humidity.
9. Expression used by Vasco Vieira da Costa (1911, Aveiro-1982, Porto) to define what would be the "preferred orientation" of buildings "where the consideration of each of those 2 determining factors of orientation (insolation and dominant winds) yield solutions that do not conjugate." In Vasco Vieira da Costa, Cidade Satélite nº 3, CODA Porto, ESBAP, 1984 (1948).
10. Kultermann, Udo, Neues Bauen in Afrika, Wasmuth, 1963.

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