Chapter 54
An Environmental Technological Approach to Architectural Programming for School Facilities

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Abstract This chapter describes synthetically a method integrating functional, technological and environmental aspects of architectural programming for school facilities. This method is based on the analysis of activities and relevant user needs followed by an in-depth assessment of all related functional and environmental aspects usually not considered in current design practices: from the climate response to comfort requirements to the analysis of energy and material flows; from the space–time characteristics of activities to their private/public connotation and interdependency; from the inside/outside interrelationships to the multisensory perception of users. This building programming phase represents a necessary background for the next preliminary architectural composition based on the environmentally sound combination of “virtual” space units through a set of rules aimed at fulfilling the client brief and general sustainability requirements as well as avoiding or, at least, balancing potential conflicts by a tradeoff approach.

Keywords School building • Environmental design • Architectural programming • Site analysis • Building regulations

1 Introduction to Environmental Architectural Programming

Public buildings have a deep symbolic significance, as they rise to the role of spaces available to citizens. This characteristic is particularly strong in buildings at educational institutions representing not only a space of study for the youth but also a place for learning in which citizenship awareness is formed. Today, a new stringent feature is being added to this concept: the need to reach environmental sustainability by complying with the requirement of nearly zero-energy buildings as
established by European Directive EPBD 2010/31/EU for the construction of new public buildings starting from 2018. To achieve this objective, new, or radically refurbished, school buildings will have to be designed taking environmental architectural programming into account whereby educational effectiveness and sustainability will be assessed against a benchmark of much higher quality than the current one.

The difficulties in achieving this goal are several, including, for example, an urgent need for modernizing the majority of existing school buildings, providing them with new functions as well as restoring them from their current state of physical and structural deterioration; the need to integrate aesthetic aspects into environmental and operational features; and, last but not least, the difficulty of finding the necessary project funds.

The aforementioned approach needs to be applied since the earliest design phases and, specifically, the architectural programming phase. Architectural programming is the preliminary design phase dealing with the organization and analysis of information necessary to develop the subsequent design phases in a rational and coherent manner.

Conventional architectural programming deals with general information and standards compliance and is generally based on a prescriptive morphological approach (e.g., quantitative dimensional rules to be followed – minimum area, height, windows area). The subsequent building design phases (configuration of layout, volume, and materials) are carried out in compliance with the standard prescriptions. In contrast, environmental-technological architectural programming includes general information, analysis of activities, needs, and requirements (ANR) according to a performance-driven approach aimed at designing buildings in response to user needs, without confining oneself to any particular shape or dimension, and the definition of indicators as tools for measuring the design performance. When this approach is used, a preliminary phase, before the schematic building design (predesign), is carried out on space unit layout and technological strategies (virtual configuration) in order to check performance vs. requirements (compliance check).

1.1 Environmental-Technological Architectural Programming

“Activities and environmental systems can be considered as the explanation of human needs and of what they tend to express: they allow for identifying the expected behaviours of users and the relevant requirements based on which designers and producers of technological systems will construct buildings” [1: 115]. The main purpose of the building design process is the realization of projects able to organize the complexity generated by both the user-activity
program and the related responses to the needed framework (UNI 7867/4). In addition, building design must ensure liveability and environmental quality [2–5].

A performance-based design of a building involves the identification of the following items:

(a) Activities to be performed in the building;
(b) User needs related to those activities;
(c) Requirements that spaces and technological systems must have in order to meet user needs;
(d) Flows that need to be considered, defined as “the movement of persons, goods or materials, in their specific location” [1].

According to Standard UNI 8289: 1981, activities are grouped by affinities of time and space in *environmental units*, and the portion of space in which one or more environmental units are carried out is called a *spatial element*. Environmental units and spatial elements constitute an environmental system. Analogously, the same standards define a *technological system* comprising *technological units*, i.e., a group of compatible functions necessary to fulfill user needs and requirements, and *technical elements*, i.e., building products able to perform the functions of one or more technological units.

The need-requirement system defined by Standard UNI 8289: 1981 is categorized into three main classes: structural (static and dynamic structural safety); operational (usability, management, and integration); context (sociocultural physical) [4]. A subsequent standard – UNI 11277: 2008 – introduced a framework of needs related to the eco-compatibility of a building and the interrelation to the phases of its life-cycle assessment. In addition, Directive CEE n.106/1989 defined six mandatory requirements for construction products to be traded within the European Union states: safety of use; durability; safety against fire; hygiene, health, and environment; protection against noise; energy savings; and heat conservation. A seventh requirement is under development and discussion: sustainability.

In parallel to the typological and topological classification established by the aforementioned UNI standards, the environmental architectural programming approach suggests a modal-dynamic classification to define and analyze activities and relevant needs/requirements. These are classified by modal categories: space–time mode, relational mode, dimensional mode, and physical mode. In the space–time mode, activities are characterized by the time of day and time of year at which they are carried out; their place of execution (external, internal); their “proprioceptive” feature (whether stationary or in motion). The relational mode is related to the privacy level of an activity (individual, group). In the dimensional mode, activities are classified based on the number of people that are involved and the size of the required space. In the physical mode, activities are classified by the material and energy input/output flows involved in the process characterizing their execution.

A synthetic representation of the architectural programming process as a basis for the preliminary design phase according to an environmental/technological approach is shown in Fig. 54.1 [6].
2 A Methodological Application: Environmental Architectural Programming for School Buildings

In this paragraph, the environmental architectural programming method described previously is applied to school buildings. As an introductory note, it must be highlighted that the national legislation implemented for this type of building (D.M. 12/18.12.1975) is more specific, from an environmental point of view, than for other types. In fact, it specifies minimum requirements with respect to, for example, space dimensioning and occupation density in relation to different environmental units; airflow rate (air change per hour); and the classroom average daylight factor. In addition, school buildings’ design can be based on good practice criteria given by the standard UNI 10339:1995 and shall comply with the national legislation for public buildings regarding execution procedures (D.M. 236/14.1989), elimination of architectural barriers (D.P.R 503/14.07.1996), and fire prevention (D.M. 26.08.1992).

The environmental architectural programming for school buildings is characterized by the following sequence of operations defining:

- A dimensional matrix based on the national standard minimum requirements;
- A matrix of activities according to the modal classification described earlier, and related to functional units, which include activities to be performed for a specified main function;
- A matrix of input/output flows – energy, materials, waste – related to the identified functional units;

Fig. 54.1 Environmental-technological architectural programming and predesign
Virtual spaces as tridimensional spatial unit elements related to the identified functional units and characterized by specific dimensions and a virtual envelope;

- A matrix of requirements of the virtual spatial units with relevant envelope characteristics and aggregation rules;
- A hypothesis of localization of the aggregated virtual spatial units on a site-microclimate matrix;
- A template for the compliance check of environmental requirements for technological units and technical elements related to the functional and spatial units.

As an example, the previously described sequence of operations is applied to a junior high school building as follows. Based on the aforementioned Italian legislation, this type of building includes classes of functional units related to the following activities: didactics, group activities and services, complementary activities, physical education, outdoor activities, and residential activities. Didactics includes instructional design, teaching models, assessment practices, human development and curriculum development, and classroom teaching, as well as special activities (art, computer science, linguistics, science, and music). Group activities and services include trips to the library, extracurricular activities, eating in the cafeteria, and hygiene services. Complementary activities include administrative, management, and technical services. Physical education includes activities for physical wellness, sports, and taking care of one’s body. Outdoor activities include physical education, sports, and recreational activities. The residential category may include, for example, a room for the janitor.

Taking as an example procedure the class of functional units related to didactic activities, the previously listed sequence of operations is described as follows.

### 2.1 Dimensional Analysis

A dimensional analysis for the functional and relevant spatial units belonging to the class of didactics activities is to be carried out in relation to the minimum requirements set by the specific Italian legislation as mentioned earlier. The list of functional/spatial units with the minimum requirements in terms of floor area units (m²) per student is shown in Table 54.1. This table also includes empty cells for client brief requirements – which coincide with the law’s requirements in the case of a public school building – and for design data with a relevant compliance check.

### 2.2 Activities Analysis

The activities related to each of the functional units listed in Table 54.1 are classified (Table 54.2) based on the modal approach mentioned earlier, which includes daily and seasonal schedules, location (indoor or outdoor), type of action
Table 54.1  Dimensional matrix: didactic activities

| Class of functional unit | Functional unit | Spatial unit | DM 18/12/75 index (12 classrooms, 300 students) [m²/student] | Client brief requirements | Number of special units | Floor area (m²) | Index compliance check |
|--------------------------|-----------------|--------------|---------------------------------------------------------------|----------------------------|------------------------|-----------------|-----------------------|
| Didactic activities      | Teaching        | Classroom    | 1.8                                                           |                            |                        |                 |                       |
|                          | Artwork         | Special didactic space/class | 0.76                                                           |                            |                        |                 |                       |
|                          | Computer        | Linguistic   |                                                               |                            |                        |                 |                       |
|                          | Science         | Music        | Musical space/class | 0.13                                                           |                        |                 |                       |

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Table 54.2  Analysis of activities. Modal classification of activities for functional units related to didactic activities

| Functional unit | Activity        | Characteristics | Seasonal term | Schedule | Placement | Type of action | Privacy | Dimensional need |
|-----------------|-----------------|-----------------|---------------|----------|-----------|----------------|---------|-----------------|
| Teaching        | Speaking        | •               | Winter        |          | AM        | In             | Individual |          | S M N           |
|                 | Listening       | •               |              |          | PM        | Out            |          |                 |
|                 | Reading         | •               |              |          |           |                |          |                 |
|                 | Writing         | •               |              |          |           |                |          |                 |
|                 | Watching blackboard | •          |              |          |           |                |          |                 |
| Art work        | Speaking        | •               |              |          |           |                |          | S M N           |
|                 | Listening       | •               |              |          |           |                |          | S M N           |
|                 | Drawing         | •               |              |          |           |                |          | S M N           |
|                 | Painting        | •               |              |          |           |                |          | S M N           |
|                 | Modelling       | •               |              |          |           |                |          | S M N           |
|                 | Washing instrument | •          |              |          |           |                |          | S S N           |
|                 | Showing         | •               |              |          |           |                |          | M L N           |
| Computer and linguistic | Speaking | •               |              |          |           |                |          | S M N           |
|                 | Listening       | •               |              |          |           |                |          | S M N           |
|                 | Reading         | •               |              |          |           |                |          | M N             |
|                 | Writing         | •               |              |          |           |                |          | M N             |
|                 | Using PC        | •               |              |          |           |                |          | M N             |
|                 | Watching multimedia board | •          |              |          |           |                |          | M N             |
|                 | Watching video  | •               |              |          |           |                |          | M N             |

(continued)
| Functional unit | Activity       | Characteristics | Seasonal term | Schedule | Placement | Type of action | Privacy | Dimensional need |
|-----------------|----------------|-----------------|---------------|----------|-----------|----------------|---------|------------------|
|                 |                |                 | Winter       | Spring   | Summer    | Fall           | AM      | PM               | Nighttime | In | Out | Stationary | Dynamic | Individual | Group work | Floor area | Height |
| Science         | Speaking       | •               | •            | •        | •         | •              | •       | •               |           | S  | M   | N            |          |            | S          | M         | N     |
|                 | Listening      | •               | •            | •        | •         | •              | •       | •               |           | S  | M   | N            |          |            | S          | M         | N     |
|                 | Reading        | •               | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
|                 | Writing        | •               | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
|                 | Experiment     | •               | •            | •        | •         | •              | •       | •               |           | S  | M   | N            |          |            |            |           |       |
|                 | Wash instrument| •               | •            | •        | •         | •              | •       | •               |           | S  | S   | N            |          |            |            |           |       |
|                 | Watching blackboard | •       | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
|                 | Watching multimedia board | •     | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
| Music           | Speaking       | •               | •            | •        | •         | •              | •       | •               |           | S  | M   | N            |          |            | S          | M         | N     |
|                 | Listening      | •               | •            | •        | •         | •              | •       | •               |           | S  | M   | N            |          |            | S          | M         | N     |
|                 | Reading        | •               | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
|                 | Playing music  | •               | •            | •        | •         | •              | •       | •               |           | S/M| M/L | N            |          |            |            |           |       |
|                 | Singing        | •               | •            | •        | •         | •              | •       | •               |           | S/M| M   | N            |          |            | S          | M         | N     |
|                 | Dancing        | •               | •            | •        | •         | •              | •       | •               |           | S/M| M/L| N            |          |            |            |           |       |
|                 | Watching blackboard | •       | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
|                 | Watching multimedia board | •     | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |
|                 | Watching video | •               | •            | •        | •         | •              | •       | •               |           | M  | N   |              |          |            |            |           |       |

S small, S small, N normal, M medium, M mediu., H high, L large
(resting or moving), level of privacy (individual or group activity), and qualitative dimensional requirements (floor area and height of spatial unit).

2.3 Flow Analysis

Analysis of input/output flows related to activities of the functional units belonging to the class of didactic activities is shown in Table 54.3. This table reports the system analysis of inputs and outputs for each specific activity. The following types of flows are considered: energy, acoustic, materials, emissions to air, water, and ground, and flows impacting indoor air quality (IAQ).

2.4 Virtual Space Characterization

Several examples of the application of functional diagrams, mainly related to distribution and communications rather than environmental requirements, can be found in the literature [7–9]. To facilitate the architectural programming process as a predesign tool oriented toward a sustainable approach, a method based on the concept of virtual space is proposed. A virtual space is a parallelepiped volume representing a spatial unit with specific dimensional and modal characteristics and environmental requirements related to the functional unit, as well as the relevant activities with which it is associated. The façades of its envelope are compass-oriented and characterized by climate–environmental requirements as well as rules for unit interrelationships and locations on a site (Fig. 54.2a). These façades are virtual, i.e., not yet technologically defined.

The environmental requirements of virtual spatial units, as well as their façades’ characteristics and rules of interrelationship and location, make it possible to aggregate them in an organic manner to determine the basis for designing a sustainable school building. In addition, a correct site-climate analysis is crucial for the completion of the environmental programming process. To this end, a method based on the microclimate matrix that makes it possible to assess the optimal location of activities and related spatial units depending on solar and wind access/protection [2, 3, 10–12] can be used as shown in Fig. 54.2b. An example of virtual spatial characterization for a school building’s functional units in relation to various dimensional, relationship, modal, and environmental requirements is shown in Table 54.4.
Table 54.3  Analysis of flows (input and output) for activities related to functional units belonging to class of didactics

| Functional unit | Activity | Electricity | Heating <100 °C | Heating >100 °C | Daylight | Ventilation | Thermal flow <50 °C | Thermal flow >50 °C | Low sound volume | Medium sound volume | Ground | H₂O | Vegetation | Inorganic | Organic | sewage | Grey water | Airflow | CO₂ | Smell | Smoke | CO | Radon | VOCs |
|----------------|----------|-------------|----------------|---------------|---------|-------------|-------------------|-------------------|-----------------|------------------|--------|-----|-----------|----------|--------|--------|-----------|--------|-----|-------|-------|----|-------|-----|
| Teaching       | Speak    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Listen   | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Read     | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Write    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Watch out | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | multimedia| *            | *               | #/no          | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
| Artwork        | Speak    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Listen   | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Draw     | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Paint    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Mode     | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Wash     | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | instrument| *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Exhibit  | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
| Computer and   | Speak    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
| Linguistic     | Listen   | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Read     | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Write    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Use PC   | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Watch out | *            | *               | #             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | multimedia| *            | *               | #/no          | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
| Science        | Speak    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Listen   | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Read     | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Write    | *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
|                | Experiment| *            | *               | *             | *       | *           |                   |                   |                 |                  |        |     |          |          |        |        |           |        |     |       |       |    |       |     |
| Wash instrument | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Watch out blackboard | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Watch out multimedia board | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Music | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Speak | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Listen | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Read | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Play music | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Sing | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Dance | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Watch out blackboard | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Watch out multimedia board | • | • | • | • | • | • | • | • | • | • | • | • | • |
| Watch video | • | • | • | • | • | • | • | • | • | • | • | • | • |

# Attention to glaring

No traditional slide projector
2.5 Environmental-Technological Assessment

The following step of environmental architectural programming is a technological envelope characterization, whereby a virtual space’s façades acquire a form associated to technical elements (e.g., windows, walls). This operation is still related to a predesign phase characterized by a list of needs and requirements, as well as their relevant performance check, as shown in Table 54.5 for an example of a technical element (window).

| Symbol | SU requirement | Facades characteristics | Facades orientation and position on site |
|--------|----------------|-------------------------|------------------------------------------|
| ☀️      | solar exposure (winter) | at least one façade facing outside with window | South, out of shade |
| 🌞      | solar protection (summer) | no more than one façade facing outside with window | North, East, or in shade |
| 🌬️      | wind exposure (summer) | at least two façades facing outside with windows or vents | Facing prevailing summer wind direction out of shade |
| 🌬️      | wind protection (winter) | no more than one façade facing outside with window or vents | Ewest with respect to prevailing winter wind direction or in shade |
| 🌞      | daylight need (DN ISO solar radiation) | at least one façade facing outside with window | North, or in shade |
| ⬅️      | adjacency to other space units | A primary SU shall have at least one façade facing outside | Facades’ link to other SU’s shall be based on functional compatibility and considering noise insulation needs |

Fig. 54.2 (a) Virtual space unit with its envelope (above); example of environmental requirements for virtual spatial units related to a generic functional unit of a school building (below); (b) virtual spatial units of a school building related to different functional units and relevant dimensions (above); placement of virtual spatial units on a plot according to environmental requirements and a site-microclimate matrix (below)

2.5 Environmental-Technological Assessment

The following step of environmental architectural programming is a technological envelope characterization, whereby a virtual space’s façades acquire a form associated to technical elements (e.g., windows, walls). This operation is still related to a predesign phase characterized by a list of needs and requirements, as well as their relevant performance check, as shown in Table 54.5 for an example of a technical element (window).

3 Conclusions

This chapter proposes an environmentally related method for architectural programming that is applicable to both retrofit and new construction projects.

The proposed method, through a series of steps comprising activity analysis, requirement definitions, and the compliance assessment of predesign options, can be applied in the early design phases to arrive at an environmentally to lead to an environmentally and technologically sustainable final building product. The different proposed tools, including checklists, templates, and matrixes, are based on both qualitative and quantitative evaluations and are flexible, adaptable, and iterative. Their application implies the contribution of an environmental consultant or a designer with environmental knowledge.
Table 54.4 Dimensional, modal, relationship, and environmental characterization of virtual spatial units to be associated to functional units of a generic school building

| Virtual space | ID | Dimension | Unit connection | External connection | Outdoor connection | Axiality | Centrality | Focused communication | Bidirectional communication | Natural ventilation | Mechanical ventilation | Daylight | Direct solar | Glaring protection |
|---------------|----|-----------|----------------|-------------------|-------------------|----------|------------|----------------------|--------------------------|-------------------|---------------------|-----------|--------------|------------------|
| Classroom     | 1  | ☐         | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Art workshop  | 2  | ☐         | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Computer and language room | 3  | ☐         | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Science laboratory | 4  | ☐         | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Music room    | 5  | ☐         | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Auditorium    | 6  | ☐☐☐☐☐☐☐ | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Connection/corridor | 7  | ☐☐☐☐☐☐☐ | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
| Atrium        | 8  | ☐☐☐       | ☐              | ☐                 | ☐                 | ☐        | ☐          | ☐                   | ☐                        | ☐                 | ☐                   | ☐         | ☐            | ☐                |
### Table 54.5: Template for environmental requirements compliance check of a technical element (window) characterizing the technological unit “façade” associated to a virtual spatial unit (classroom) belonging to the functional unit “teaching” of a school building

| Environmental requirements | Functional unit | Teaching | Spatial unit | Classroom |
|---------------------------|----------------|----------|--------------|-----------|
| **Technological unit**    | Classroom system | Technical element | Windows |
| Needs and requirements   | Performance assessment |
| **Class of needs**        | **Need**        | **Life cycle phase** | **Class of requirements** | **Requirement relevance** | #Required performance level | **Design performance level** |
| Comfort, hygiene, health | Perceptive, sensorial comfort | Operational phase | Thermal comfort | H | VH | |
|                          | Visual comfort | H | VH | |
|                          | Acoustic Comfort | M | VH | |
|                          | Olfactory comfort | – | – | |
|                          | Tactile comfort | – | – | |
|                          | Proprioception comfort | M | H | |
|                          | Electromagnetic radiation | H | H | |
|                          | IAQ | H | VH | |
|                          | Indoor toxicity | VH | VH | |
| Rational use of resources | Rational use of climate and energy resources | | Solar gain for winter heating | H | VH | |
|                          | Solar control | H | VH | |
|                          | Use of natural air movement for cooling | H | VH | |
|                          | Air infiltration control in winter | H | VH | |

*L low, M medium, H high, VH very high

*From regulation and client brief*
When functional and environmental components are not taken into account after the preliminary design phases, the possibility that their further integration may result in significant adjustments to the building project with consequent increases, by a proportional factor, in costs and time is very high. The integration of these factors in an advanced design phase, in order to restore the levels of quality of the design, is, in fact, difficult and is often resolved with improper and nonintegrated solutions. Instead, a designer should be able to integrate the various components of the project from the beginning through the necessary tradeoff between aesthetic and functional values.

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