Lights and shadows in university classrooms

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Abstract

"How important are considered the light conditions and the visibility in university classrooms?" and "In relation to which of these objectives: the well-being of the users, and / or the fitness of the educational setting, and / or the proper use of the energy resources?". Furthermore, "In which way, natural lighting is supposed to contribute to these goals? These questions, seemingly rhetorical, showed up in to their relevance, during a research work on the performance evaluation of university classrooms, that is part of a wider project, called "City Studies - Sustainable Campus", aimed at increasing and improving the sustainability practices of the university campuses in Milan.
This research was to detect, through a process of post occupancy evaluation, the main problems in terms of comfort and lighting, of some classrooms of the Architecture and Engineering schools, placed in one of the buildings of the first campus of the Politecnico di Milano, undergone to adaptation works over time.
Therefore, a technical audit of the building layout, of the equipment and of the lighting conditions of the classrooms, as well as some observations on the way of use of the space and a users' inquiry were carried out in subsequent stages. This method turned out to be effective, since the outcomes of the on-site analysis made it possible to get a framework of criticalities, problems and unsatisfied needs. On this basis, it could be possible to outline proposals for the building performance improvement that are sustainably oriented, while ensure the comfort as well as meet the user's needs, too.
Despite its practical purposes, this evaluation activity allowed, in the meantime, to develop an analysis of the behaviors and of the selection criteria, both of the students –in terms of use of spaces and adaptation to places - and of the buildings managers - in the intervention programs for meeting continuously updated needs and purposes. The results of this analysis show a widespread lack of attention to the correct use of the available resources and to the opportunity of exploiting the natural light. Moreover, this disattention affects more and more, due to its occurrence in those places specifically aimed at a projectual education.
All this brings us back to the need both of critically rethinking the initial questions -due to the evident distance, even in academia, between theory and practice; and of in increasing empower strategies of awareness of the environmental dimension of our actions.

Keywords: lighting performances, post occupancy evaluation, simulation, university, well-being

Introduction:

How important the natural light in the interior on the welfare of people is generally known and widely discussed in the literature, from different point of view. Natural light is also more and more considered a basic element to get high levels of environmental sustainability in buildings too. For these reasons, the daylighting has assumed increasing importance in the design of educational spaces, as reflected by design guides, by reports of new schools project, by the evaluations of the existing ones; there have been even experimental studies on the daylight effects on pupils performance.
In Italy, lighting performance are governed by compulsory rules only in schools and not in university classrooms. Consequently, daylighting is scarcely considered in the projects for universities, especially when aimed at works for interior transformations and adaptations. Moreover, the lighting component is often held in low regard, in planning strategies and actions for energy savings.
This paper presents a research work based on the hypothesis that the proper use of natural and artificial light could affect the well-being of the users and the fitness for purpose of the educational setting, as well as the energy saving goals, in universities too. So, the research was aimed at investigating the relations between lighting conditions and students' behaviour and perception of the classrooms quality; as well as, at highlighting their effect on comfort, usability and energy saving, in a university building that has been modified several times.
The opportunity of this experimental activity came from the join of the Politecnico di Milano, together with Università degli Studi to the International Sustainable Campus Network. It was presented a project called "Città Studi Campus Sostenibile", aimed at transforming the whole university neighbourhood in a model area in Milan, as regards to life quality and environmental sustainability. The project covers four thematic areas

(People, Energy, Environment & Accessibility), where individuals or groups can develop research works, with the goals of experimenting innovation, of promoting changes in life style and of getting more liveable spaces.

The Milano Leonardo Campus is the oldest of the present seats of Politecnico di Milano and it was inaugurated in the area of Città Studi (a large university settlement in the eastern area of Milan) in 1927. Over time, to meet new needs, Politecnico di Milano first built new buildings and later started a continuous process of modification and adaptation of those existing. Most of those works were carried out without an overall plan, through single interventions on small areas, in a short time. For this reason, not all the building performances could always be taken into due consideration.

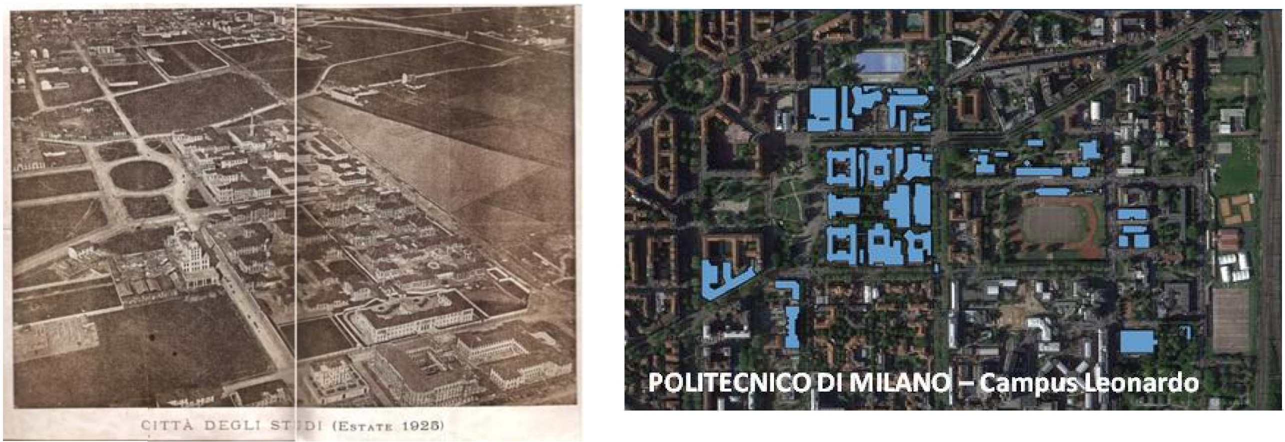

Figure 1 Città Studi with Politecnico di Milano and Università degli Studi, in 1925 and nowadays

The authors of this paper joined the Environment work group of Campus Sostenibile and promoted a research work focusing on the topic "well-being of people". It was aimed at keeping on with the experimental research on feed-back methods for the rehabilitation of public buildings, in accordance with goals of global sustainability, as well as at focusing on lighting and visual conditions in the classrooms, since they seemed to have been neglected in most of the past works of adaptation and/or retrofit.

The case study

The case –study is the "Edificio 2", one of the oldest buildings in the Milano Leonardo campus. It has a quadrangular court plan, with the extension of two auditorium classrooms in the north and south sides, and it has a ring distribution by arcades on the ground floor and by a corridor on the first floor and of the courtyard. Over time, several transformations of the lay-out and of the use of the interiors have been undertaken and a new floor was added both in the east and the west side.

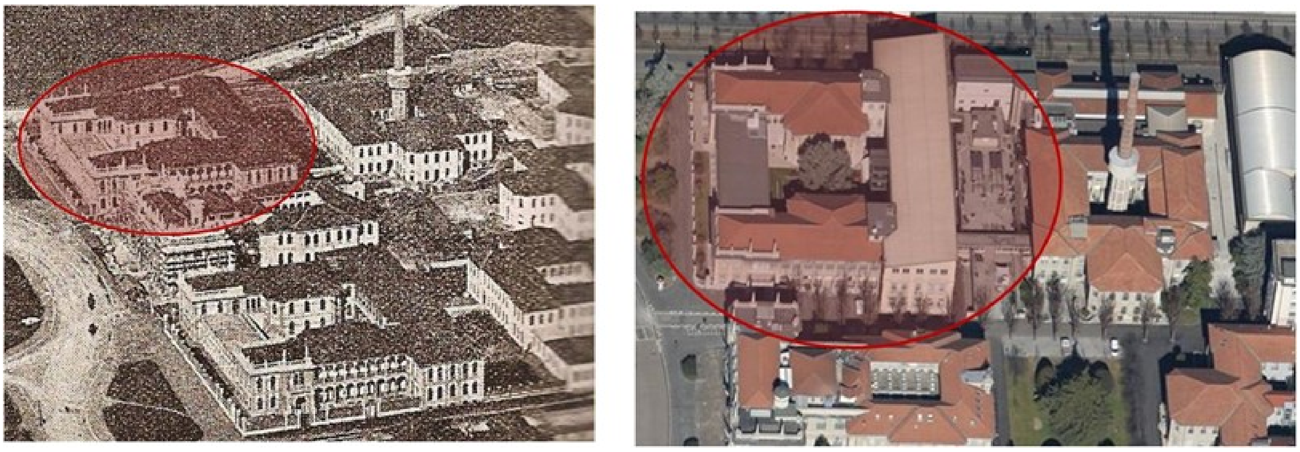

Figure 2. Politecnico di Milano with "Edificio 2", in 1925 and nowadays

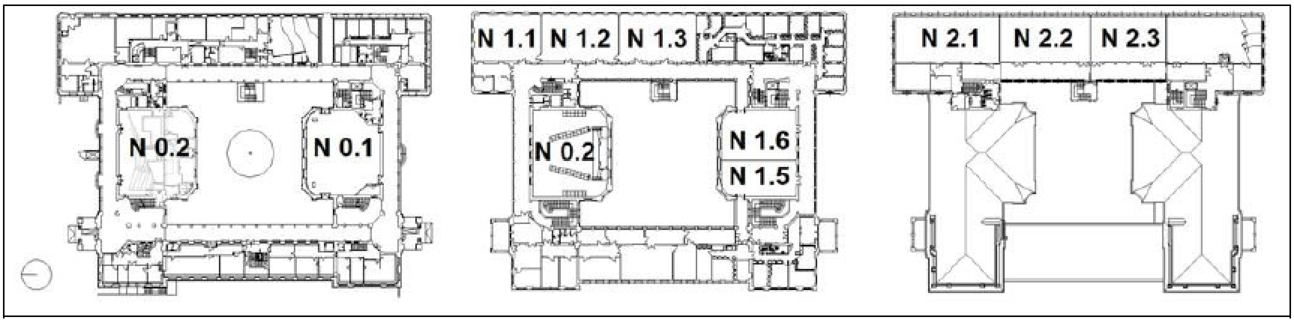

Figure 3, Politecnico di Milano, "Edificio 2", map of classrooms

Referring to the didactic areas, at ground floor the north auditorium classroom is the only one still preserved (N.0.2) both in its shape and furnishing, while the south one has been divided in three flat classrooms for lectures, one with the entrance at ground level and two at the upper one (N.0.1, N.1.5, N.1.6). In the east side, there are three classrooms both at first and second level. At the first one they are equipped for lectures (N.1.1, N.1.2, N.1.3), while, at the upper one (N.2.1, N.2.2, N.2.3), there are those for workshop activities. The classrooms at the ground and the first levels are used for two or three hours' lectures for engineering classes; those at the second level are for whole day's workshop courses for Architecture.

Analysis Methodology

The evaluation process has been developed according to the criteria of POE, by the means of different methods and techniques, in order to get a systemic and balanced picture of the main problems.
Indeed, the evaluation of the effective conditions included a functional analysis of the whole building as well as a technical audits and light performance simulations in the classrooms. Then a behavioural analysis highlighted in which way the classrooms were used. Lastly, a users' inquiry allowed to bring out how different building performance are evaluated and considered by different classes of students and to be informed about their seats selection criteria.

The *functional analysis* has allowed us: to detect and map the intended use of all areas of the building, to correlate the kind of use to different types of spaces, in order to bring out strengths and weaknesses.

The *technical audits* was focused on the fixture, the fittings and the equipment of the classroom, especially referring to students' posts. It was taken into account also: doors, windows, lights and switches, dimming elements and movement systems.

The *behavioural analysis* was aimed at bringing out the general conditions of overcrowding and / or underuse, but also at correlating the behaviour of students to the conditions of the classrooms.
It was observed the classrooms in terms of: occupation levels, students' presences and distribution in the available seats, users' control of lighting conditions, of heating, cooling, etc. The analysis was carried out in the spring time and lasted a week, with various surveys a day in each classrooms.

For the *users inquiry*, it was produced a special questionnaire to collect data both on students' selection criteria for choosing their seat places, and on their evaluation on performance levels and on relevance of thermal comfort & air quality, of natural lighting, of artificial lighting, of visibility of the board, equipment & services. The survey was developed on a sample of five different classrooms, with the participation of about 600 students.

Light performances simulation

Lighting conditions have been evaluated in terms of requirements to perform certain activities. Illumination levels are indicated by specific rules. In particular, in this paper we refer to the European standard EN 12464-1 (lighting in the working spaces), that takes into account three visual needs:

- visual performance (working people are able to carry out their visual works even in difficult situations and for a longer periods)
- visual comfort (the comfort sensation indirectly contributes to improve the productivity)
- safety

The requirements, expressly stated for classrooms for drawing by hand, are 750 lx, even if this activity is currently almost completely replaced by CAD-aided design that does not require high levels of illumination.

This means that even in the drawing classrooms, to carry out activities in appropriate conditions, light levels may be even lower. However, the analysis considered the 2 values of 300 and 500 lx in all types of classrooms. In particular, in the drawing classrooms in which the drawing activity takes place the reference value is 500 lx and 300 lx in the places for lectures and tutorials. For the latter, it must also be said that in many cases, lessons are kept with the aid of slides projected on a screen by a video projector, which often make 300 lx not necessary.

The lighting conditions were analyzed by simulating the distribution of lux levels in the various classrooms.

The main objective of the method is to determine the number and the lighting appliance distribution in order to define the adequate condition for the task. Table 1 report the data of the standard UNI EN 12464-1 related to the schools.

Type of interior, task or activity	Em (lx)	UGR_L	Ra	Notes
Classrooms	300	19	80	Lighting should be controllable (never under 200 lx)
Lecture hall	500	19	80	
Technical drawing rooms	750	19	80	
Black board	500	19	80	Prevent specular reflection
Computer practice rooms (menu driven)	300	19	80	See lighting of workstation with display screen Equipment

Table 1: Overview of tasks in a classroom together with the requirements for the illuminances according to the European standard UNI EN 12464-1. Em is the minimum required average illuminance (i.e. maintained illuminance) per task; UGR is the upper limit for direct glare. Ra is the lower limit for the color rendition index

To analyze the lighting conditions of the classrooms, it was appropriate the use of a simplified simulation program that took into account the same external lighting conditions for the various areas and allow to vary the conditions (day with overcast sky to have only the diffuse light in regardless of the orientation, combination of natural light and artificial light).
The most commonly used systems take into account lighting devices and the characteristics of the space, in terms of size, shape and color (surfaces reflection coefficients).

For the simulations, the free software Dialux was used. Light planners are allowed to solve any planning task, considering natural and artificial lighting. The software is the realization of an industrial consortium for the development of a constantly updated light planning tool to meet the changing requirements of light planners all over the world. Luminaire manufacturers have the opportunity to present their products individually on this independent platform.
The geometric configuration was define in the program for each single classroom, as well as the internal and external windows position and dimension, and the desks position. In the end, the light bulbs system (2x54 watt and 4x 18 watt) and their position were defined.
Every single classroom was analyzed in two different time periods of the year- may and December- since they are the most crowded moments of the two semesters and in two different lighting conditions: diffuse natural light (cover sky) and natural and artificial light at the same time.

Outcomes

From the evaluation activity, very different situations among the classroom blocks have emerged. A first division can be made between the classrooms facing the internal courtyard (N0.1, N0.2, N.05, N0.6) that are very deep and with a limited amount of natural light and those in the east block (N1. 1, N1.2, N1.3, N2.1, N2.2, N3.3), which instead have large openings on the long side. Furthermore, in the courtyard the rooms derived from the division of auditorium (N0.1, N0.5, N0.6) seem to have the most critical conditions as regard to lighting, comfort, etc.; on the contrary, in the east body those at the second floor (later added) have better performance than the below ones.

As regard to the ways of use, in the classrooms for lectures of the engineering courses, most lessons last about two or three hours and the use of the blackboard prevails over the slide projector; on the contrary, in those for architecture workshops, the use of the projector is very frequent, due the need to show pictures. Moreover, in these latter, the class activities last the whole day and are very diversified; this implies the need for the users to be able to adjust quickly and easily the lighting conditions, both natural and artificial.

Then, how students choose where to sit in the classrooms depends on the type of teaching activity, on the number of available seats, on the easily of movement among the seats.
Single common element in all classrooms of the building is that the position of the desks does not follow any criterion linked to the natural light; it depends on the location of the plants and the need to maximize the seating posts as more capacity as possible. Indeed, in all classrooms for lecture the space available for each seat is less than 1 m^2, and as consequence the movement area is very small.

The *classroom N0.1* seems to be the most problematic in the building. It is very large and is located on the south side and has north-facing windows and it is half the height of the N0.2 auditorium. The windows on the north wall produce very low levels of natural light and even coming from the students' back. For this reason, the use of artificial light is constant. Lighting conditions with artificial light are definitely satisfied, since they reach 500 lx; lighting devices are in large numbers and well distributed in five parallel lines perpendicularly to the seating rows. In this case, the risk could be an over-illumination, both because most activities in this classroom could be well developed with 300 lx and especially because the light intensity cannot be modulated, since the power is controlled by a sensor that can only turn on or off all the equipment simultaneously.

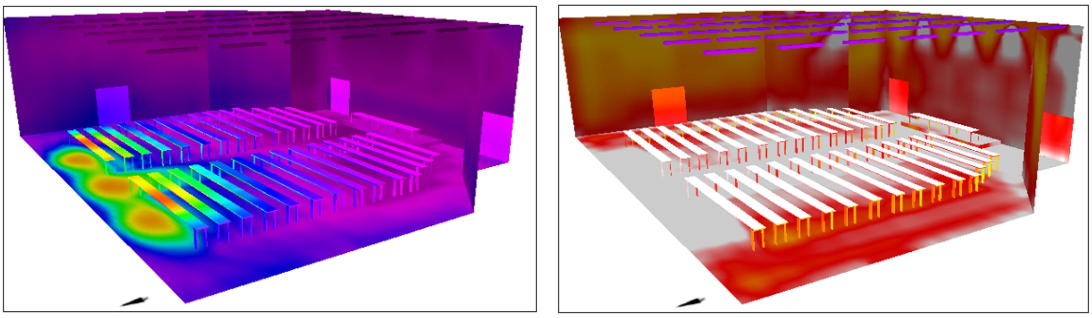

Figure 4. Comparison of simulations of the lighting conditions carried out with the free software Dialux in classroom N0.1 in May. On the left only natural light is considered, as on the right both natural and artificial light are considered at the same time

Due to the progressive reduction of the size of the classes, the classroom is equipped with a quantity of seats really higher than the number of students enrolled in the courses, so always there are far less students than seats. They usually gather in the front seats or spread themselves at the ends of the rows (that are quite long). By the inquiry, they confirm to prefer the seats near the teaching post or the doors (these latter, and also the windows, are kept open during lectures for air circulation), while windows are totally no attractive. Then, referring to the classroom performances, only artificial lighting and equipment & supplies have got a positive evaluation (light were always on during lectures); on the contrary, thermal comfort & air quality and natural lighting have had the worst score of the whole building.
This negative evaluation and consequently also the students' uncomfortable condition have been even enhanced by the relevance that they have attributed in their answers to thermal comfort and air quality, as well to the visibility of the board.

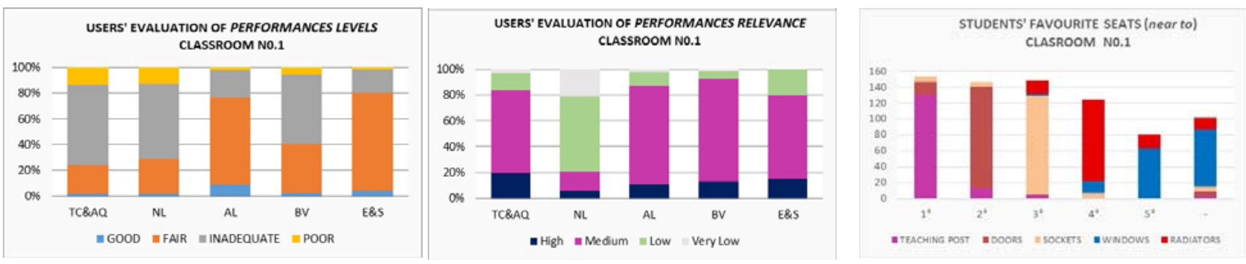

Figure 5. Users' Inquiry. Students' evaluation of performance quality and relevance, so as of seating preference in classroom N0,1

The *classroom N0.2* is an auditorium with original furnishing, in specular position with respect to the N0.1, so it faces south on the courtyard. Natural light comes from the top of the southern wall and reaches values close to 500 lux only in the higher seats in May, while in winter, and always in the seats below, the values are much lower. In any case, the light comes from the wall behind the students, and is therefore unusable. Artificial light is always in use, even if homogeneous and appropriate values are never reached; values around 400 lx can be achieved on the writing surfaces in the central area, while they remains between 50 and 150 lx at the sides. This is because the lighting system consists of punctual elements, placed along the central area, from top to bottom and they have a no adequate intensity.
Also this classroom is equipped with more seats than the present need, and they are also quite uncomfortable, as well the stairs are very steep. As consequence, the students gather in the front seats, where the visibility of the blackboard is better. The different shape of this classroom (double volume per same number of seats) has produced better students' evaluations of performance than in the N0.1, except for the equipment.

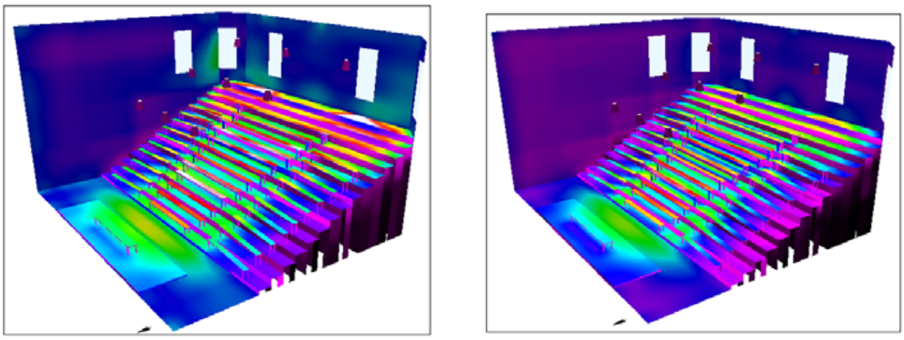

Figure 6. Lighting conditions in classroom N0.2 simulated trough the free software Dialux taking into account natural and artificial light at the same time. On the left simulation on May, on the right simulation on December. Very few differences underline the insignificance contribution by natural light in the whole year.

The two *classrooms N1.5 and N1.6*, at the first floor, come from the division of the same square auditorium than the N0.1; consequently both they resulted in a too wide rectangular shape, with the short side facing north on the courtyard.
They are specularly oriented, so in N1.5 the natural light comes from the left side of the stations, while in the N16 arrives from the left side. Nevertheless, lighting conditions are very similar: the natural light is very inadequate in the whole year, since it is never more than 100 lx on the writing surfaces; while, through artificial lighting, high levels of illuminance are provided.

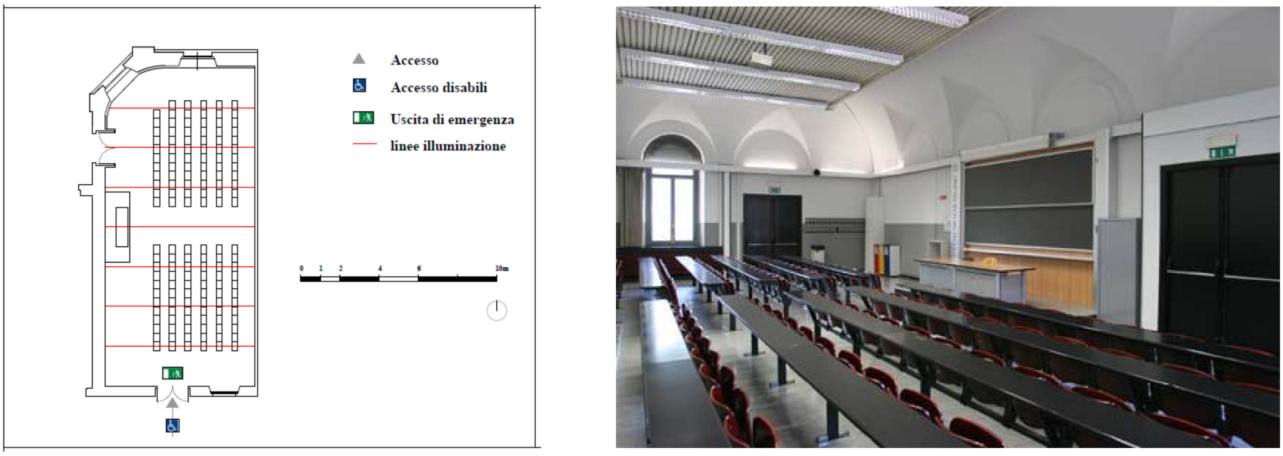

Figure 7. Layout, fittings and equipment in classroom N1.5

In particular, even in the classroom N1.5, the lighting equipment (consisting of seven parallel lines, placed perpendicularly to the rows of seats) may be excessive. In fact, considering all the lighting devices turned on, the light distribution on the desks and on the floor results higher than in the N1.6. Also in this case there is no control system, aimed at allowing users to adapt the lighting to their needs (that may vary during the day) and at avoiding unnecessary energy consumption.

These classrooms are smaller than the lower and so there are less rows of seats and usually only few of them are vacant. Consequently, students sit everywhere, starting from the back rows.
Even in these classrooms, they have declared to prefer sitting close to the teaching post and to the doors, but here the windows follow in third position. It probably depends on the possibility to look at outside, and also on the fresh air, since they are used to keeping the external door open to get fresh air inside. Indeed, even if the classroom performances have been much better evaluated, natural light (as well as equipment) has not been considered too relevant for them.

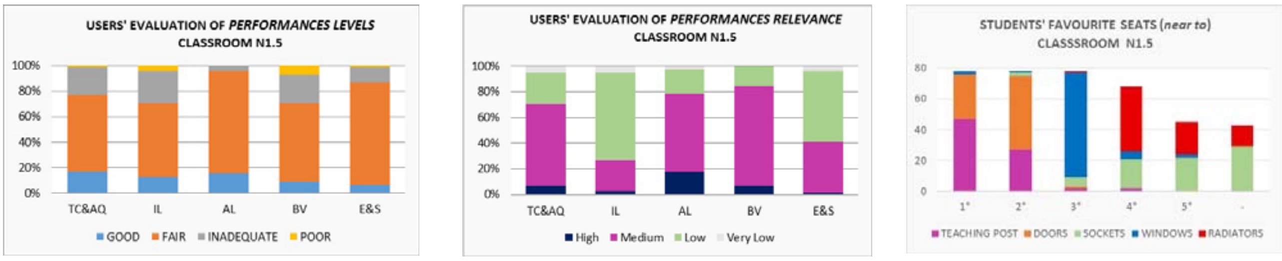

Figure 8. Users' Inquiry. Students' evaluation of performance quality and relevance, so as of seating preference in classroom N1.5

As previously mentioned, the block of classrooms on the east side is on two floors and there are significant differences between them. First, they accommodate different kind of courses and are differently equipped; then, also their windows change for size and shape.
A peculiarity of this block is related to the fact that lighting conditions change throughout the day, due to the east orientation. In fact, if in the morning it is possible to have direct radiation at least on the tables closest to the windows, in the afternoon there is only diffuse radiation (in the simulations this variable has been limited by the fact that we consider overcast conditions and thus homogeneity of sky).
As for the openings and therefore to the luminosity conditions, another difference is that two classrooms (N1.1 and N2.1), have windowed surfaces both on the east and the north side, and so the light comes from the left and from the back of the students. Nevertheless, the simulation shows that the natural light never reach 500 lx, even in these classrooms.
The *classrooms on the first floor (N1.1, N1.2 and N1.3)* still maintain the shape of the '20s, while they have been renoved in their interiors. They are used and equipped in similar way to the flat classrooms just described. However, the different configuration, exposure, and opening to the outside, as well as the manual control of power, allow to reduce the use of artificial lights in the classroom, that have been often found switched off, during the survey. Even in these classrooms, however, natural ventilation is encouraged by keeping windows and doors open starting from the late spring.
In the classroom N1.1, lighting conditions are homogeneous in all positions but reach not more than 400 lx,that is considered sufficient for the type of activity placed there.

The classroom N1.3 is the smallest and it has been recently modified regarding the seats orientation; so, now the natural light comes from three windows back the students. Consequently, natural lighting conditions are inhomogeneous and only some tables in the last rows, closest to the windows, seems to be in a good condition; however, coming from back, this light becomes quite little useful. In order to achieve good condition in the entire class, it is therefore necessary to switch on the lamps, also in this case arranged in two parallel rows and perpendicular to the direction of the tables.

As concerns the modes of use, in addition, it was noted that in most days, these classrooms are occupied at most to half of the capacity. When there are many vacant places, the students tend to gather in the front rows, but in the classrooms N1.1, N1.2, there was also a trend to seat along the window side; while that did not occur in N1.3, where windows are back the students.

The two *classrooms N1.5 and N1.6*, at the first floor, come from the division of the same square auditorium than the N0.1; consequently both they resulted in a too wide rectangular shape, with the short side facing north on the courtyard.
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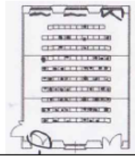
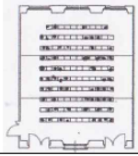
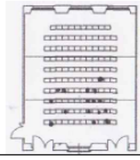
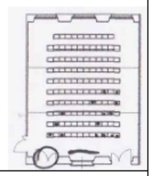
	DATA: 01/06 ORE: 09:40 CONDIZIONI METEO: **SERENO** ATTIVITA': **LEZIONE** CONDIZIONI IN AULA: **- 2 TENDE CHIUSE** **- LUCI SPENTE** **- 1 FINESTRA APERTA** **- VENTOLE ACCESE** **- 1 PORTA APERTA** COMFORT PERCEPITO: **ACCETTABILE** 	DATA: 01/06 ORE: 12:05 CONDIZIONI METEO: **PARZ. NUVOLOSO** ATTIVITA': **LEZIONE** CONDIZIONI IN AULA: **- TENDE CHIUSE** **- LUCI SPENTE** **- FINESTRE APERTE** **-LUCE LAVAGNA ACCESA** COMFORT PERCEPITO: **ACCETTABILE** 	DATA: 01/06 ORE: 14:55 CONDIZIONI METEO: **NUVOLOSO** ATTIVITA': **LEZIONE** CONDIZIONI IN AULA: **- LUCI SPENTE** **- TENDE APERTE** **- FINESTRE APERTE** **- VENTOLE ACCESE** COMFORT PERCEPITO: **BUONO** 	DATA: 01/06 ORE: 16:50 CONDIZIONI METEO: **SERENO** ATTIVITA': **LEZIONE** CONDIZIONI IN AULA: **- LUCI SPENTE** **- FINESTRE APERTE** **- TENDE APERTE** **- LUCE LAVAGNA ACCESA** **- VENTOLE ACCESE** **- 1 PORTA APERTA** COMFORT PERCEPITO: **BUONO** 

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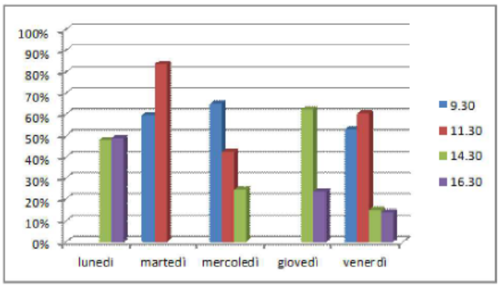

Figure 9. Behavior analysis. Maps of the students' seating choices, and monitoring data of the occupied seats, in classroom N1.3

The inquiry highlighted a very negative evaluation of thermal comfort and air quality performance, that however have always been considered relevant. Less negative the evaluation of other elements and above all for the lighting, even if artificial lighting is considered much more important than the natural one. Also the visibility of the blackboard has been declared relevant, much more than electrical sockets.
Students stating a preference for places close to the professor desk and the door, while the windows are in last place, preceded by heaters, although they are placed just below the windows in the classrooms.

The *classrooms on the second floor (N2.1, N2.n2, N2.3)* have lower height and windows larger; consequently, the lighting ratios, and especially the aerating ones, are better than those below. There are not fitted with rows of fixed writing surfaces but with movable tables, thus, they accommodate a smaller number of student places, with around 3 m2 of surface available for each ones.

In these classrooms are carries out activities as ex-cathedra lectures (often with video projection) and work at the tables with different tools, like notebooks, drawing equipment, etc.
Students can move and change their place, depending on the type of activity and the condition of visibility of the blackboard from different points. For example, during the lectures with the use of video-projected images students are placed in the front of the screen, while during the workshops, i.e. student activities that increasingly required the notebook use, students tend to place along the perimeter of the classroom, where are typically located electrical sockets.

Figure 10. Various ways of use in different lighting conditions in classrooms for Architecture workshops, here the N2.2

The different way of use changes the students' choice criteria, in fact, they have declared to prefer to sit near the sockets position and the doors; the teacher post follows in the third position, while, in this case, the windows are preferred to radiators, even if also here they are in the same potions. All classroom performances have been quite well evaluated, as well as all they are considered relevant for future architects.

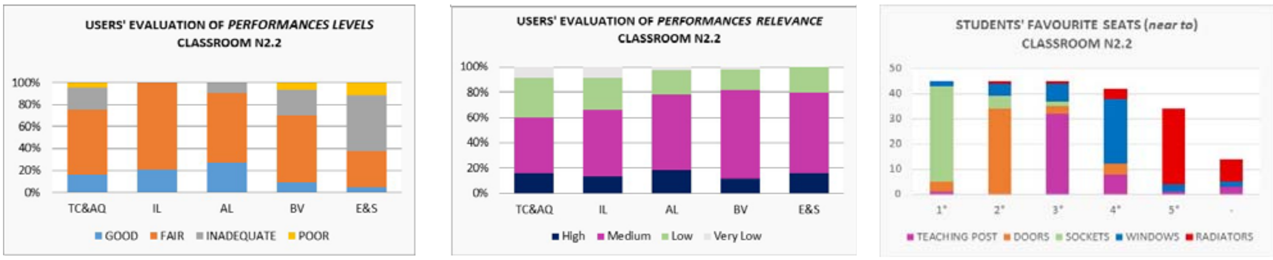

Figure 11. Users' Inquiry. Students' evaluation of performance quality and relevance, so as of seating preference in classroom N0.9

These classrooms have much more solar radiation available than those facing the courtyard. However, also on the second floor the natural light never reaches the 500 lx , nor is uniformly distributed. For different activities (except for manual drawing) light can be quite adequate (it goes from 400 lx in the areas close to the tables, to the approximately 100 lx in the areas furthest from the window). Even in these cases, in the intermediate seasons, on some worktables, the direct light sometime represents a problem, which is faced by closing the blind curtains that don't allow to adjust the light intensity.
The artificial light, always spread by three parallel lines, perpendicular to the worktables, are in sufficient numbers to ensure a homogeneous distribution and quantitatively adequate light.

In the classroom N2.1, also thanks to a greater sky view, artificial light uniformly reaches 500 lux, and indeed there may be some moments of over-lighting, hard to be avoided, due to the fact that switches are simultaneously connected to the whole lighting equipment.

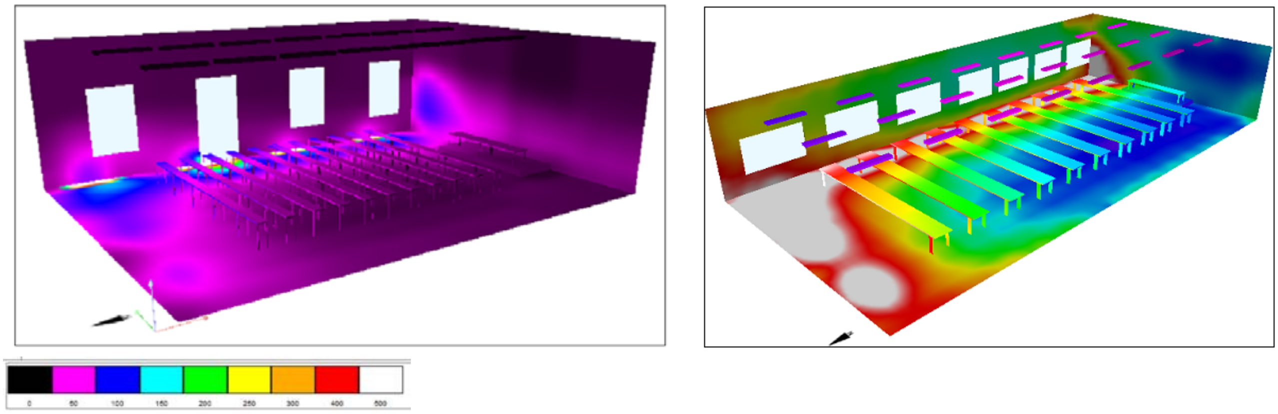

Figure 12. Comparison of simulated natural lighting conditions in the corresponding classroom in the first floor (room N1.1 on the left) and second floor (N21 on the right). The differences evidence the contribution due to the natural light that varying according to the different height and sky opening

In the classroom N2.2 the lack of homogeneity in the natural light distribution (never enough) comes out clearly both in December and in May, but in the month of May on the desks near the windows there are up to 200 lx (lower limit of the level required for classrooms). Through the artificial lighting, it is possible to achieve a high brightness, but not the 500 lx, except for the locations close to the windows and in the more luminous months.

Conclusion

The results of this work outline two different lines of future development in relation to the initial hypotheses.
On the one hand, it has been confirmed the hypothesis that, in the interventions of adaptation of the built, lack of attention to the overall system building performance produces critical functional situations and impacts on people's well-being. In the face of this, it seems appropriate that, under the future sustainability strategies of the Politecnico di Milano, they could outline some processes and actions, aimed at increasing awareness of the importance of natural light in relation to well-being and energy savings, both in their building technicians and in the users (professors and students).
In addition, it highlights the opportunities to plan a set of works, aimed at improving the conditions of the users and at pursuing energy saving objectives, in the case study. The range of works can be very broad and of different impact. As appropriate, in fact, could be called into question: the present use of some classrooms; their space layout; the seating capacity; type and orientation of the work posts, fixture, fittings and equipment, materials and colours. However, to ensure effective change in strategy, these should be part of a larger project aimed at integrating and better exploit the contribution of natural lighting (so as the ventilation, the external views, etc.), as well as at dimensioning appropriately artificial lighting; but above all at ensuring adequate adjustability to the users, in both cases.
In fact, the need to adjust the level and distribution of light clearly emerged, both with respect to the different educational activities, and the variations of time (daily and seasonal) and weather. This objective could be pursued in different ways such as: by supplying curtains with different levels of darkness, by sectioning the distribution lines of lamps with different switches, by inserting individual lights at the posts.
In addition, there is a clear need of increasing the integration of different equipment and different plant systems for lighting, thermal comfort (in winter and summer), for the use of work equipment. This is in order to prevent negative interference, taking into account the variety of needs and ways of use, and also to promote rationalization in energy use.

As regards, however, the hypothesis that natural lighting is of significant importance for the well-being in learning environments, the outcomes of this work rather than give answers, seem to multiply the possible questions, and so open towards future development; that would be necessarily characterized by high levels of transdisciplinarity.
In fact, from the behavioural observations and the users' inquiry, some interesting items came out, especially with regard to engineering students.
In the classrooms for architects, in fact, the best lighting conditions (although not perfect), the flexibility of the setting and the greater freedom of movement, can justify the good evaluations expressed by students; as well as the fact that the demanding functional requirements (availability of electrical sockets and visibility of the screen and blackboard) predominate in the seating choice.
Very different, instead, is the situation of engineering students, who seem the least interested at the presence of natural light in the classroom, even when this is significantly lacking and the visual condition are uncomfortable. Certainly, the type of activities (only ex cathedra) and the shorter lasting of these, favour a total concentration to the blackboard, and reduce the degree of general attention at natural lighting, which is not recognize as a real need.
It is, therefore, doubtful whether this lack of interest depends really on the insignificance of natural light on their welfare conditions, or on their adaptation to any learning environment they use. But also, how they would behave if they had the opportunity to choose the type of classroom, in relation to different performance (first of all to the natural light), rather than changing their classroom, etc.

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