Date: Friday **10th of December 2021**

Time range: **09^{00}-16^{55}**

REEHUB PLUS / 1ST CROSS BORDER EVENT

“SMART CITY OPEN INNOVATION FORUM”

ORGANIZED BY: **BARLETI INSTITUTE FOR RESEARCH AND DEVELOPMENT**

SUPPORTED BY:

Speaker:

PhD. Arch. ETLEVA DOBJANI

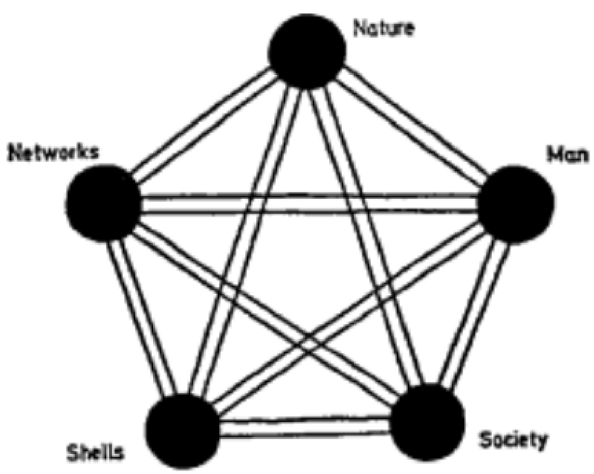
Head of the Department of Architecture and Design, Barleti University

Relation:

INDOOR ENVIRONMENTAL QUALITY INSIDE THE BUILDINGS

Constantinos A. Doxiadis, a researcher whose work is mainly focused on analyzing the quality of life inside the settlements, in the article “Ekistics, the Science of Human Settlements” elaborates on how we can make a judgment about the quality of architectural space:

“A judgment about quality can be made in several ways in terms of **the relation of each individual to his/her environment** - that is, the individual’s relation to nature, society, shells, and networks - **and the benefit that he/she gets from these contacts.** We can measure his relations to ***air*** and to its ***quality***, to ***water*** in his home; and **we can express judgments based on the measurements of many physical and social aspects of the cities**.” (D.70)



Fourth principle: optimization of the quality of man's relationship with his environment.

From Science, v.170, no. 3956, October 1970, p. 393-404: 21 fig.

The concept of **quality of life** related to the **living/work/study space is complex**, because it includes various environmental and social factors. **If we look at history**, the perception of the architectural space has been changed not only **according to its size,** but also in terms of its structure as well as its **adaptation** to the change by the elements that are part of it. **The activities** that the users are able to have inside the living area, the environmental normative, and the architectural space has become much more complex throughout time.

“The elements that determine the quality of the living space more precisely **the quality parameters of perception, that influence the stimulus conditions, enrichment, and culture that define the psychological well-being** ... are parameters which are more difficult to be defined of quantitative parameters - ***air, temperature, humidity and electro clime - as it is not detected by instrumentation objective but by the sensory capacity of the individual***. <u>The senses mainly "know", define the space around through differences of stimulus: hot / cold; light / shadow; near / far; smooth / rough etc.</u>” (Souza, 2003)

Some researches referred to the quality of space and energy efficiency of buildings in Albania

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Requalification of Residential Space in Tirana - Methodologies and Intervention Strategies

Etleva Dobjani

Arch. PhD, University POLIS, Tirana, Albania

Issue	E3S Web Conf. Volume 312, 2021 76th Italian National Congress ATI (ATI 2021)
Article Number	02005
Number of page(s)	13
Section	Energy Efficiency of Buildings
DOI	https://doi.org/10.1051/e3sconf/202131202005
Published online	22 October 2021

E3S Web of Conferences **312**, 02005 (2021)

Achieving near Zero Energy Building in Albania: An Approach for the Retrofit of a Public-School Building

Lorenzo Belussi[1*], Ludovico Danza[1], Matteo Ghellere[1], Italo Meroni[1], Francesco Salamone[1], Arben Shtylla[2], Etleva Dobjani[2] and Saimir Shtylla[2]

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Issue	E3S Web Conf. Volume 312, 2021 76th Italian National Congress ATI (ATI 2021)
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Section	Environmental Sustainability and IAQ
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Published online	22 October 2021

E3S Web of Conferences **312**, 12002 (2021)

Assessment of Indoor Environmental Quality in schools by combining survey and modelling: a case study in Albania

Francesco Salamone[1*], Lorenzo Belussi[1], Ludovico Danza[1], Matteo Ghellere[1], Italo Meroni[1], Arben Shtylla[2], Etleva Dobjani[2] and Saimir Shtylla[2]

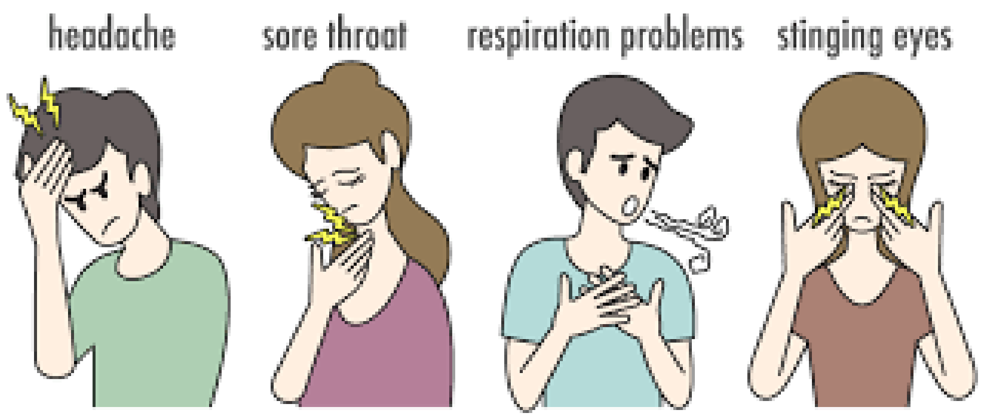
Constructive and technological systems after ‘90s and the main problem issues

The city grew up from a single function to a multi-functional center and developed in vertical level and in horizontal too. The rapid urban growth and the lack of capacities of public control because of the political transitions, influenced in the creation of an irregular urban landscape and in the low quality of the residential space. The increasing demand for new homes, created an unpleasant situation of informal parasites interventions in the facades of the buildings, both existing and new ones. The intrusion of new volumes on the existing building facades and in the urban pattern, implies a critical situation due to the lack of open collective spaces and public services. Consequently, not only the quality of the building facades that surround the open space has deteriorated, but in the meantime there were also created low aesthetic, environmental, compositional, architectural and technological quality open spaces. The presence of informal and individual interventions in the facades, without homogeneous material, dimensions or colures, has created an unpleasant façade in terms of estethic but also bad qualitative a low qualitative s[ace inside the building

The building shell plays a key role for two main aspects:

1: Energy consumption (more than 45 % of energy in Albania is consumed by buildings (residential services), 38% transport, 15% industry and 2% in others)

2: The Indoor Environmental Quality (IEQ), which is fundamental to guarantee safety, well-being, health of building occupants and their productivity as well. ***In schools, children spend about 30% of their daily-time and adequate IEQ levels are mandatory to guarantee their health and performance.***



lack of concentration

*The Indoor Environmental Quality (IEQ) is today fundamental to guarantee **safety, wellbeing, health** of building occupants and their productivity*

*Quality of life is normally taken to mean the general **well being** of people and the **quality of the environment in which they live**.*

Well-being

Positive emotion
Absence of negative emotions
Satisfaction of inside temperature
Positive functioning

Well-being

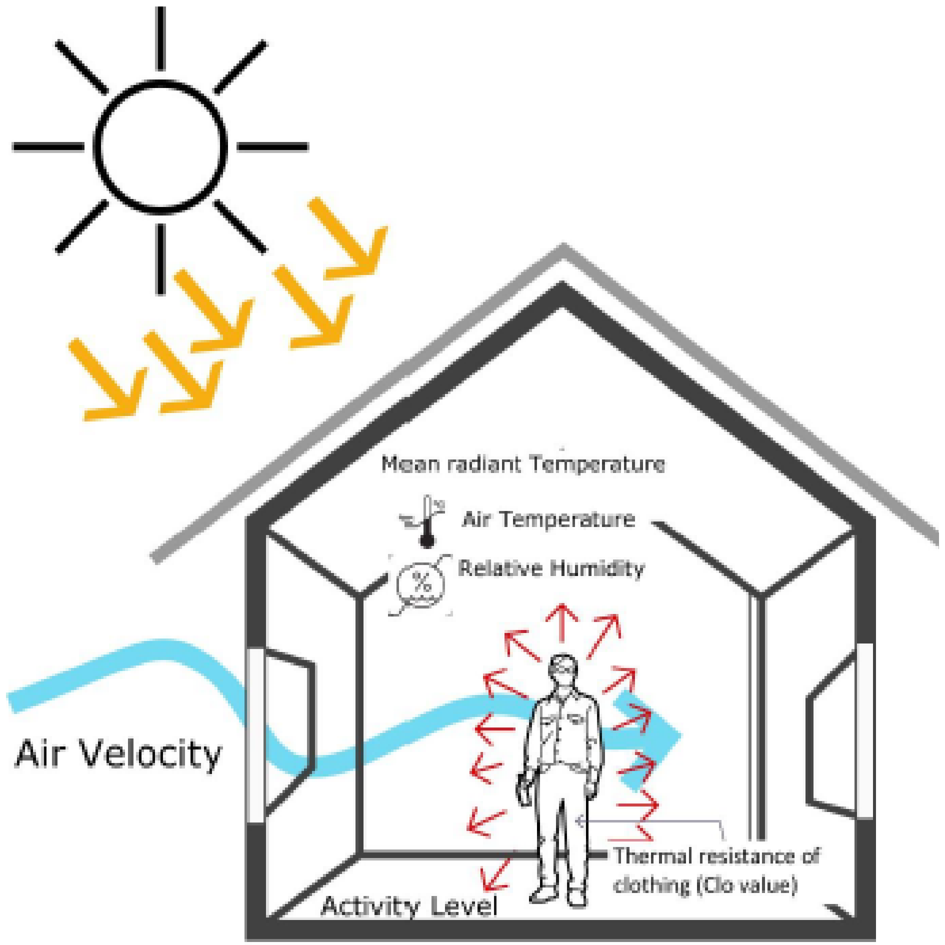
influence

Work development and economy

Physical activity

IEQ is determined by many factors, including

Lighting,
Air quality,
Damp conditions



Low IEQ levels in educational buildings directly affect pupils' performance in learning.

In **2007,** in a large campaign carried out in **several Finnish schools** combining on-site monitoring with questionnaires revealed that poor air quality was the main cause of discomfort detected. The survey identified a series of diseases affecting the pupils even if there was not a strong statistical correlation with indoor quality.

In spring **2017,** obtained similar results with a survey carried out in **21 Dutch schools**, where the major cause of discomfort was again poor air quality.

In Portuguese schools, found that Indoor Air Quality (IAQ) parameters were not being fulfilled, with CO2 concentrations exceeding national and international limits. The results of the objective measurements made revealed *low levels of IAQ* and *light in conventional schools*.

On behalf of the bilateral agreement **between the National Research Council of Italy and the Ministry of Education and Sport of the Republic of Albania,** in 2020, is organized a monitoring campaign carried out in an educational building nearby Tirana.

Open Access

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Assessment of Indoor Environmental Quality in schools by combining survey and modelling: a case study in Albania

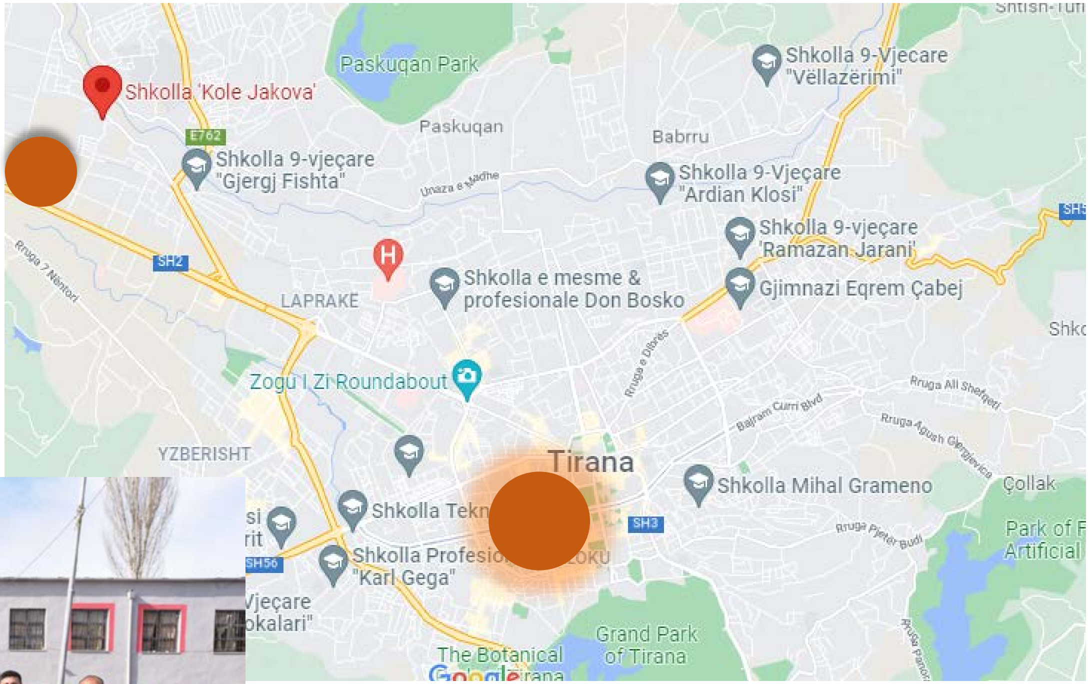
Francesco Salamone[1*], Lorenzo Belussi[1], Ludovico Danza[1], Matteo Ghellere[1], Italo Meroni[1], Arben Shtylla[2], Etleva Dobjani[2] and Saimir Shtylla[2]

The study proposes a combined approach for the assessment of the IEQ,

in the _collection of objective data_ through the environmental monitoring of indoor variables and including also **the _subjective perception of indoor environment_ by the students through the compilation of a specific questionnaire**.

“Kolë Jakova” school in Albania – case study

The objective is to evaluate the main aspects of IEQ in two classrooms in the “Kolë Jakova” school using **two smart devices** developed with the ***Do It Yourself (DIY)*** philosophy and a ***survey to evaluate pupils***’ perceptions within the indoor environment.



The school building is built in 1983 and it is among the standard school building typologies during Socialist system (1945-90) in the country also known as “Shkolla tip”.
The school hosts 420 pupils for a total of 18 classrooms of the elementary cycle and secondary cycle.
The structure is realised by load-bearing masonry walls in the whole perimeter and in the inside separate walls.

In comparison to the original design, the building underwent to partial

renovations such as the

_insulation of roof with waterproof layer on top (<u>U-value = 0.48 W/m^{2}K</u>)

_installation of heating system/

FACTS

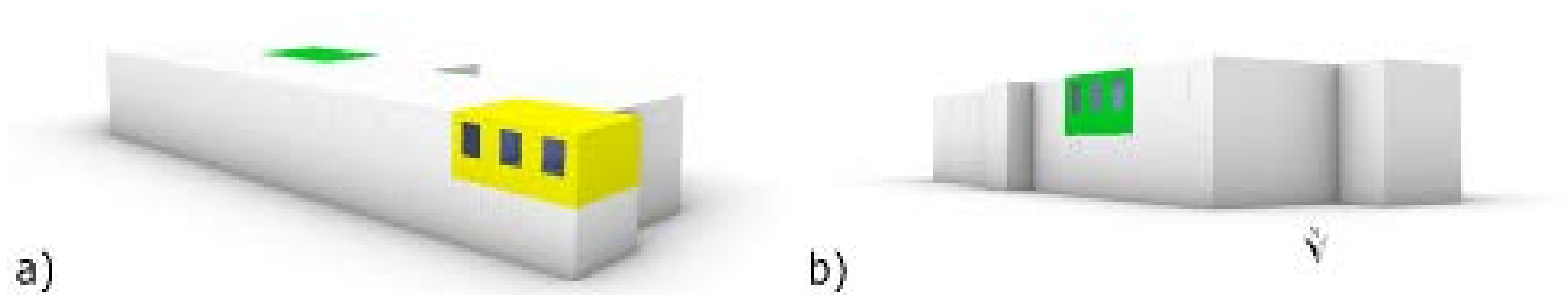
1. The external load-bearing masonry walls are uninsulated

(U-value = 1.26 W/m2K)

2. Windows (130x160 cm) are single-glazed with aluminium frame (U-value of 6.8 W/m2K and SHGC = 0.7)

Regarding the production of Domestic Hot Water (DHW), it is ensured from two separate boilers.

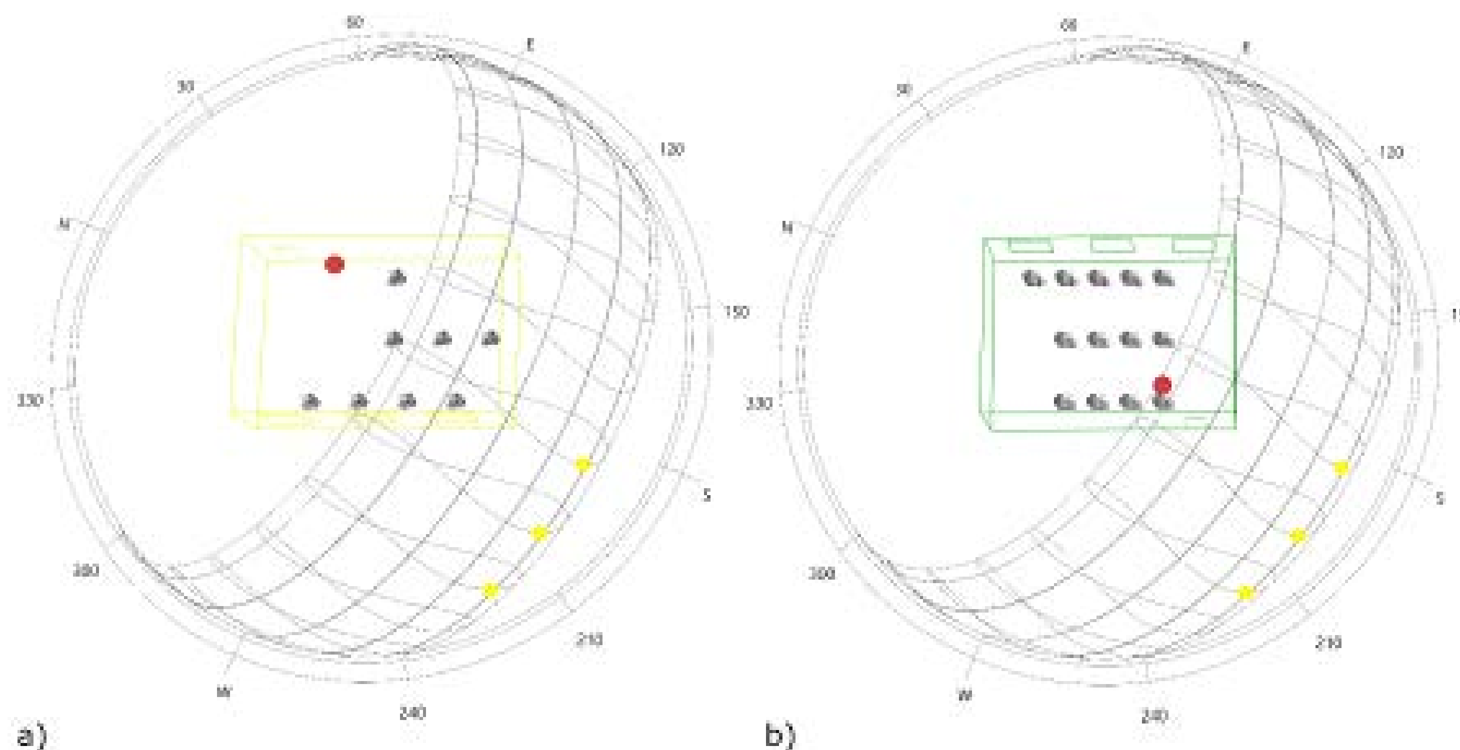
For the ***monitoring compain*** were chosen two classrooms positioned on the opposite sides to consider the exposure's impact



3D model of the school building and the chosen classrooms for monitoring campaign:

a) in yellow **class VIIIA**; b) in green **class IXB**

The monitoring campaign and the survey aiming the collection of subjective and objective data was carried out from November 16th-18th, 2020, Time interval: 1.00 to 3.00 pm. The figure below reports the positions of the students and position of each monitoring unit



VIIIA (yellow); IXB (green)

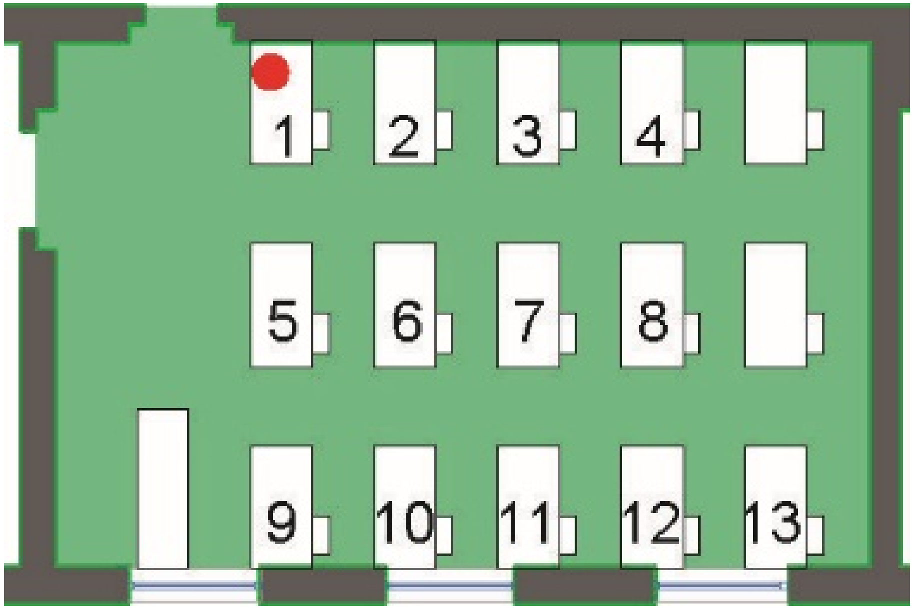
Sun path diagrams in the chosen classrooms and positions of the nEMoS devices (red dot)

The number of the pupils' per class was 21, and is collected their subjective data of their personal perceptions expressed through the compilation of the questionnaire regarding three IEQ parameters:

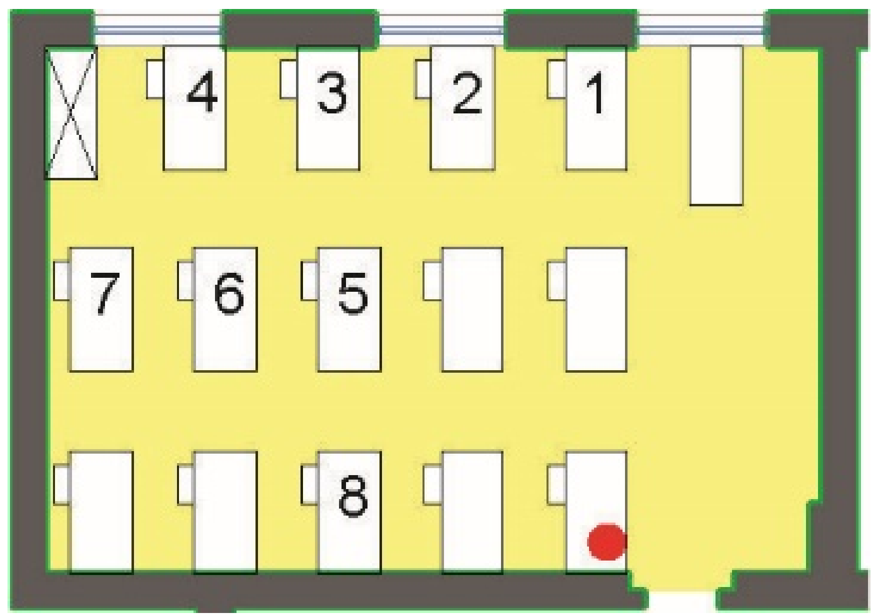
Thermal Comfort,
Visual Comfort and
Indoor Air Quality perception, in the classroom during the didactic activity.

The questionnaire was repeated for three consecutive days at one-hour intervals, between 1.00 p.m. to 3.00 p.m.

Classroom Color/N.	Participants [-] Total(M-F)	Age [y] Avg± std	Weight [kg] Avg± std	Height [cm] Avg± std	Iclo [clo] Avg± std	Met_{st} [met]
Green IXB	13(6-7)	14± 0.5	57.92± 14.38	164.32±13.01	0.73± 0.11	1
Yellow IIIA	8(4-4)	13± 0.5	50.42± 6.42	166.73± 6.62	0.78± 0.10	1



The position of the monitoring units within the classrooms was dictated by practical needs (proximity to the power supply) and requests from school staff (not to position devices in the middle of the classrooms).



1. Please indicate your thermal perception (Mark with **X** only one alternative for each hour)					
	Cool	**Slightly cool**	**Neutral**	**Slightly warm**	**Warm**
13.00					
14.00					
15.00					

2. Please indicate your visual perception (Mark with **X** only one alternative for each hour)					
	Dark	**Slightly dark**	**Neutral**	**Slightly bright**	**Bright**
13.00					
14.00					
15.00					

3. Please indicate your air quality perception (Mark with **X** only one alternative for each hour)				
	Not smelly	**Slightly Smelly**	**smelly**	**Very smelly**
13.00				
14.00				
15.00				

Structure of questionnaire for IEQ perception (translated from Albanian)

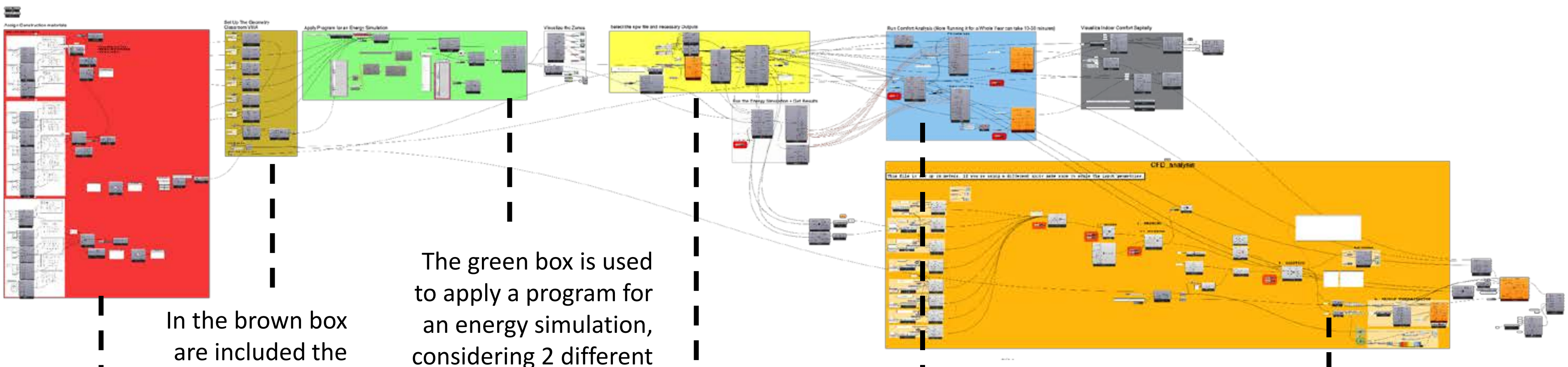
From the analysis of participants' answers it was also possible to calculate **the thermal resistance of their clothing** in compliance with Annex C of **the Standard EN ISO 7730.**
An additional thermal resistance equal to **0.1 clo** for sedentary activities due to the **standard school chair** was considered.
The **standard metabolic rate Metst** is defined in accordance with the value reported in Annex B of **EN ISO 7730.**
The **collection of the indoor environmental variables** was carried out using **nEMoS.**



Due to the limited time available for the campaign, the model was not calibrated even though the outdoor environmental data for the scheduled period exported have been considered. **The simulation was performed using Ladybug, Honeybee and Butterfly**, three of the four series of plugins of the family of Ladybug tools for Rhinoceros® software.

Ladybug, Honeybee for Grasshopper was initially used to connect Grasshopper to *validated* ***daylighting and energy*** simulation engines, such as RADIANCE, Daysim, EnergyPlus and OpenStudio. Later was added the ***thermal comfort*** models to Ladybug, which provided a foundation for detailed comfort mapping tools. With the development ongoing they allow for a wide range of analyses from climate visualization to computational fluid dynamics and have changed the face of environmental building design through their application to projects.

The model used for the assessment of the thermal comfort on each classroom is displayed



In the brown box are included the components identifying the geometric characteristics of the classroom

The green box is used to apply a program for an energy simulation, considering 2 different scenarios: 1) closed windows; 2) open windows and CFD analysis performed using Butterfly and Open Foam plugins

In the red box

All the layers composing each opaque envelope element are defined considering:

- thickness in [m],
- conductivity [W/mK],
- density [kg/m^3]
- specific heat [J/kgK] of the material.

For windows, the

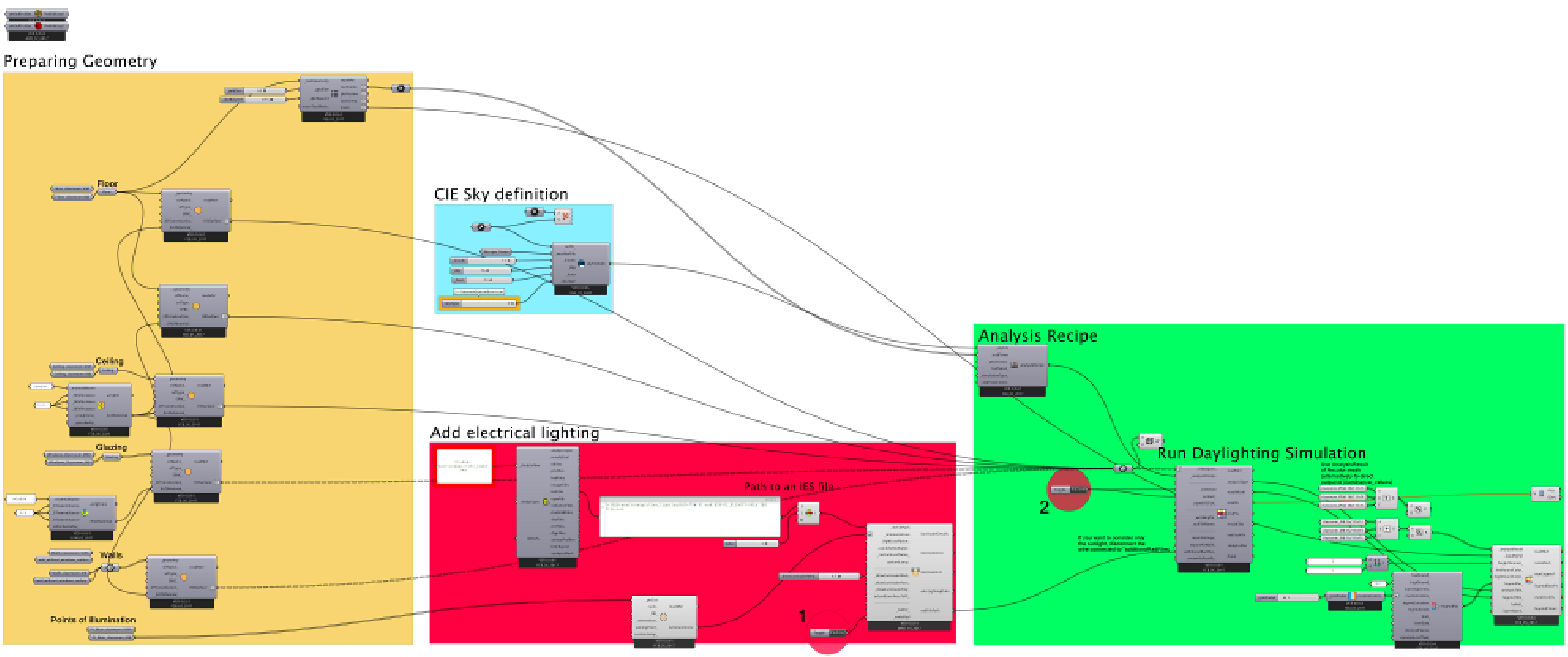
- U-value [W/m^{2}K],
- SHGC and the
- Visible Transmittance

The yellow box is used for the definition of the EnergyPlus weather file (.epw)

The output of the analysis performed with OpenStudio, is afterwards connected to the Honeybee_PMV Comfort Analysis Recipe tool (blue box) that allows to define the spatial distribution of the PMV considering the output of the model and the view factors in the selected geometries.

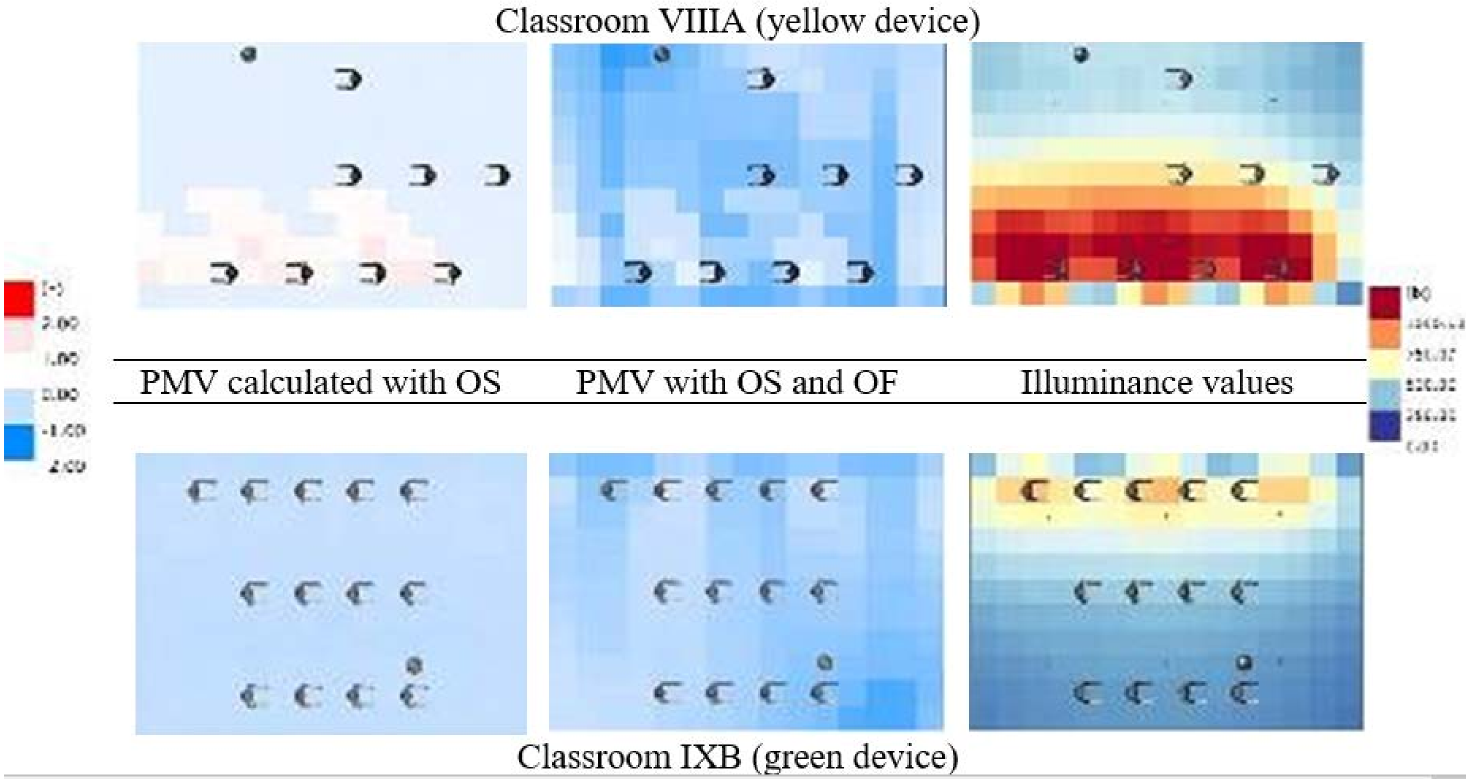
The orange area is populated by the components used for the Computational fluid dynamics analysis, thus allowing to visualize the distribution of the thermal comfort, in the case when windows and the door are opened. In this case, the geometries and meshing were modelled in Butterfly to define the OpenFoam case.

The model used for illuminance analysis was performed **with Ladybug and Honeybee** plugins and combined with **Radiance**



Starting from the definition of the geometry (brown box), in the middle, there are set the characteristics of the sky (cyan) and the electrical lighting (red).
Considering the period of monitoring phase, we opted for an intermediate sky without sun.
Lights were considered on during class time. In the green box, it is possible export geometries and all other information to .rad files and run combined daylighting and lighting analysis using Radiance.
PMV and illuminance values modelling were performed 0.75 m above floor level in accordance with the height of school desk. No model was used to simulate the distribution of the CO_2 concentration.

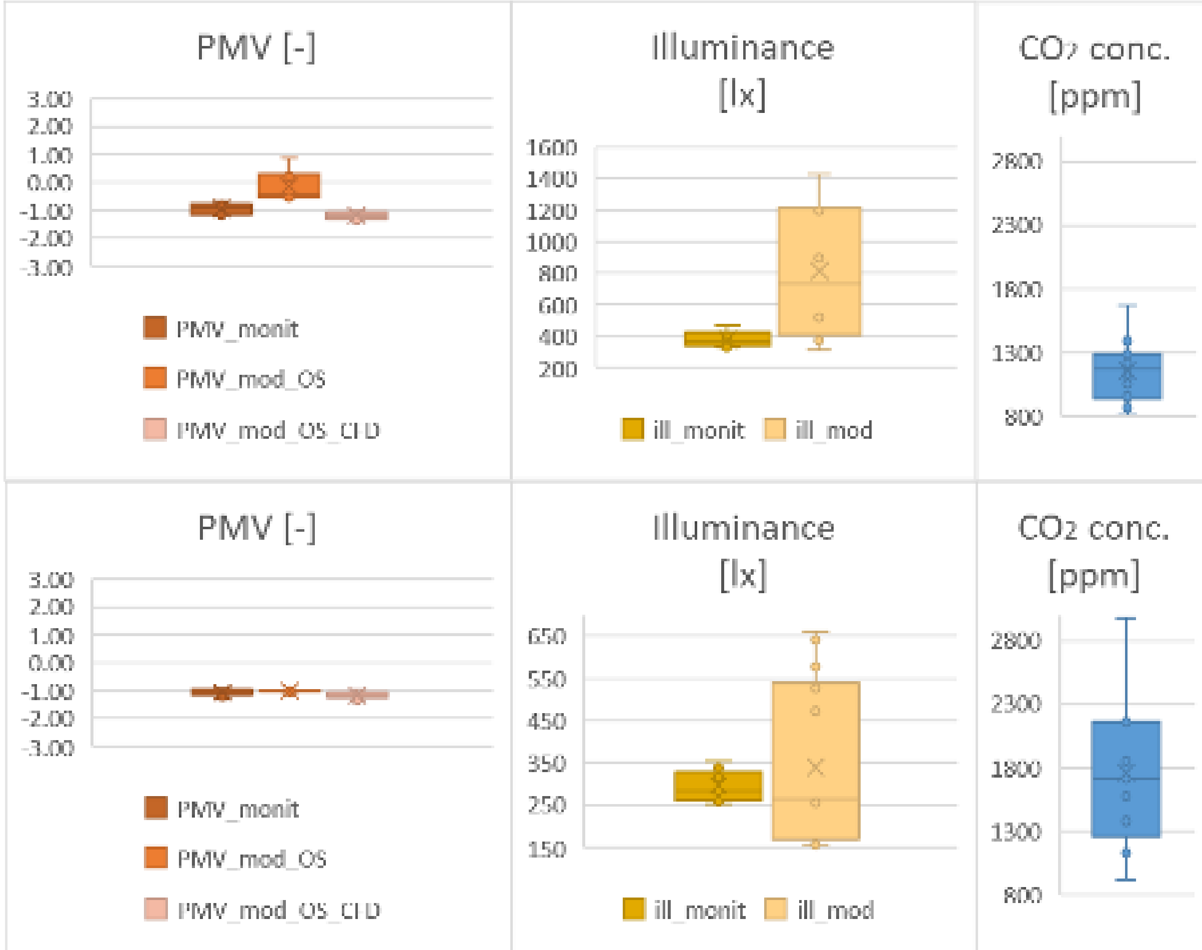
Simulation mapping of the two classrooms



Initially, the presented methodological approach allows to obtain ***results from modelling*** and subsequently compare them with ***data collected by nEMoS devices*** and ***users' feedback analysis.***

In the first scenario (closed windows), and In the second scenario (opened windows), a combined CFD and OpenStudio model was defined.

PMV mapping was performed considering the air temperature and relative humidity (RH) derived from the **OpenStudio simulation**, the radiant temperature (RT) was defined considering the **OpenStudio output of indoor surface temperatures and view factors for each of the considered test point.** Metabolic rate (MR) and thermal resistance of clothing (CLO) **are the mean values provided by students.**

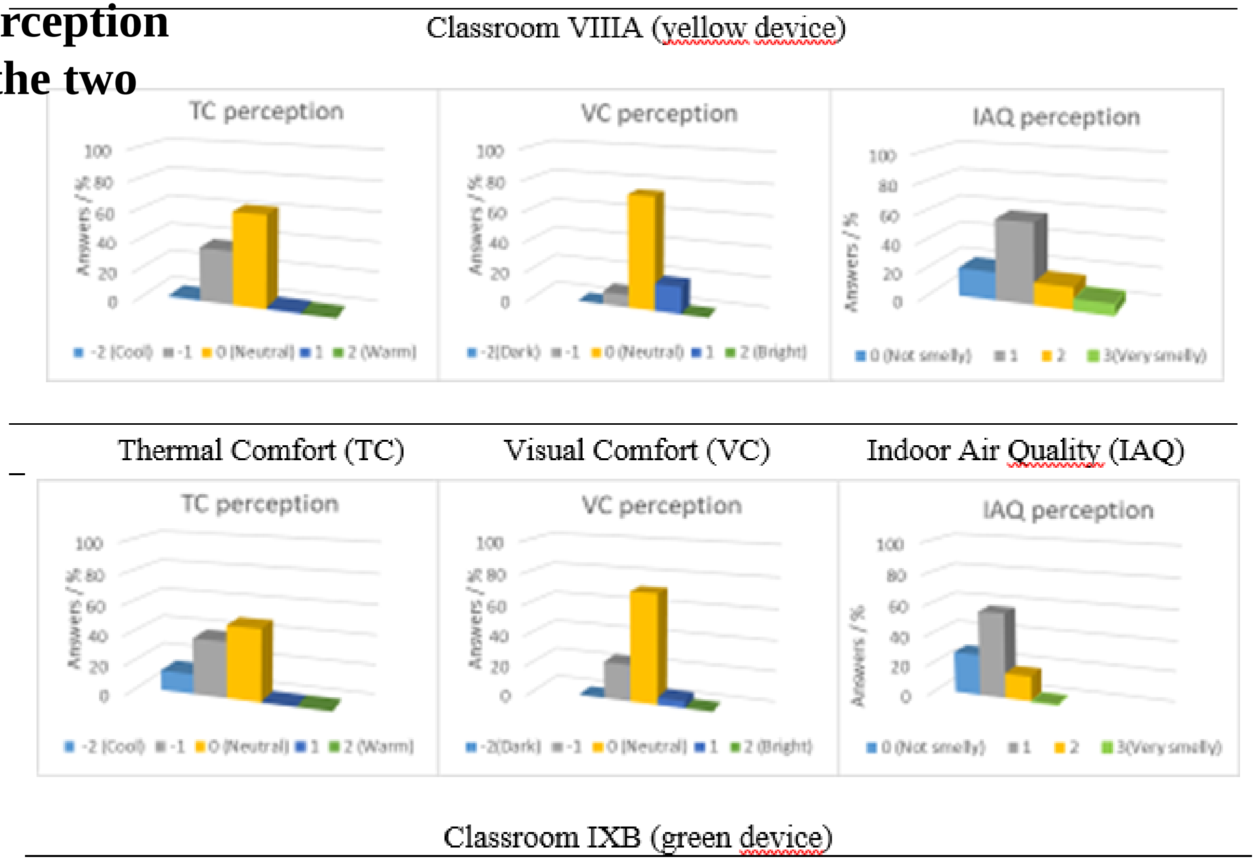


Classroom IIIA
(yellow device)

Classroom IXB
(green device)

The comparison of PMV values highlights similar results between modelling and monitoring data.
In class VIIIA, OpenStudio plus CFD modelling produces closer PMV values than the simple OpenStudio model. On the other hand, the comparison of Illuminance values shows a limited convergence of results respect to monitored data. Unlike the modelled ones, real illuminance values have a limited fluctuation over the time, because only one measuring point was considered, far from the windows. The average modelled illuminance value of IXB is closer to that monitored.
Finally, reports the data of Thermal Comfort (TC), Visual Comfort (VC) and IAQ as perceived by students.

Subjective perception responses in the two classrooms



The analysis of **TC** shows a higher neutral perception of students in IXB classroom in comparison to the VIIIA classroom (62% vs 48%) and a lower “-2 – Cool” perception (0% vs 14%).

In the analysis **of VC,** 74% and 71% of the students respectively of the IXB and VIIIA classrooms, neutral perception was the most common. In IXB classroom the percentage of pupils that felt the “slightly bright” condition resulted more than three time higher than in the VIIIA classroom (18% and 5% respectively). At the opposite, the “slightly dark” perception is three time higher in VIIIA than XIB (24% and 8% respectively).

Finally, the results regarding the **IAQ** perceptions partially reflect the analysis of the corresponding monitored data (CO_2). Despite a consistent difference in the CO_2 concentration values (in the IXB value is 600 ppm higher than in the VIIIA classroom), only 7% of the students in the IXB classroom perceive the air as “very smelly”, while the most common perception in both classrooms is “1 – low smelly”. Probably, it may be related to the low sensitivity of students to air quality, considering that the other IEQ aspects are more immediate to assess (i.e. room brightness, temperature level).

CONCLUSION

It is appropriate to remind some important limitations of the monitoring campaign and survey.

1. it was performed in an unusual period (pandemic situation worldwide)

→ presence of about half of the total number of students during the didactic activity.

2. The study is related to the duration of the monitoring campaign: only three days that are not enough to perform the calibration and validation of the models.
3. only one monitoring point (The modelling confirmed the necessity to use more than one monitoring point)
4. using low-cost sensors and 3D-printed techniques

Furthermore, it gained lot of attention from the students in both classrooms, with the expectation to grow further their interest towards a topic of growing interest such as (IoT) and their awareness about the importance of indoor comfort issues. In this perspective, it might be possible to bring students close to the themes of IEQ and technology.