

# Methodologies for the Design of University Teaching Spaces in Covid/19 Regime. A BIM Oriented Approach, Defined for the Case Study of the Buildings of the Department of Architecture of the University of Florence (DiDA)

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**Abstract.** The research, carried out at the University of Florence, investigated the tools and methodologies needed to manage the setting up of educational environments in a dynamic-emergency regime. It tested the interoperability of the digital tools deemed necessary for an integrated management of space management activities. And defining a methodology for setting up the spaces assisted by the use of digital systems capable of automating the design activities

**Keywords.** Safe accessibility; School building; COVID-19; Space management; BIM-Interoperability.

## 1. Introduction

As a result of the Covid-19 pandemic event, the need has emerged to redefine the rules concerning the management of the use of spaces in relation to the types of users, the types of activities and the environmental features of both buildings and spaces of social interaction. From this point of view, the pandemic revealed the need to manage the design of the use and arrangement of spaces and equipment with performance assessment methods which take into account different time requirements, modes and types of users. Identifying new quality solutions related to the relationship between man and environment, in accordance with the rules and dynamics dictated by the succession of emergency phases. In this new scenario, which is still changing and therefore difficult to predict, the buildings belonging to the world of schooling and education in general have been affected by wide-ranging spatial transformation activities involving access methods, the use of spaces and equipment, as well as the forms of communication and interaction between users. The planning paradigms used for educational spaces in the past, which were mainly driven by issues concerning density and costs, had necessarily to be

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modified according to new performance criteria, based on dynamic regulatory-dimensional references. Topics such as flexibility of use, adaptability, safety, control of user flows, or information management, which have always been references of Design for All, have brought about, mostly unintentionally, a widespread interest that has often generated confusing design solutions. In fact, the dynamic condition of the rules regarding the use of spaces and equipment has produced a series of obvious critical issues in the management of emergency phases. Issues which are also exacerbated by a substantial absence of support tools devised for dealing with the existing variables and therefore useful in assisting the operational choices of designers/managers. The research, carried out at the Department of Architecture of the University of Florence (DIDA), inquired into the tools and methodologies necessary to determine a compositional module of reference for the design of educational spaces in a dynamic-emergency regime. The methodology was tested using the building of Santa Marta, main headquarters of DIDA, as case study, and assessing the interoperability of the digital tools considered as necessary for an integrated organisation of space management activities.

## **2. Methodological framework and phases of the research**

At the conclusion of the lockdown phase, with the gradual reopening of the university's premises under a contingency regime, both the issues of access control and of space design have necessarily undergone a general rethinking in terms of the organisation and distribution of environments. The first design responses, which regard issues specifically related to distancing, provided indications of a general nature based primarily on compliance with the ratios between the numbers of students and the square metres of classroom, the practices to be applied in the classroom regarding air changes, as well as indications concerning learning modes, which have mostly been held in blended format. In particular, the issue of the ratio between students and available square metres was the subject of indications which essentially omitted variables such as the spatial conformation of the classrooms and their articulation regarding the flow of users, learning modes, air change methods, and the types of furniture and equipment present in each school complex. In this context, the research process which was developed during the initial stages of the pandemic, was divided into 3 main phases and was aimed to provide initial answers, including those of a methodological nature, in order to optimise the set-up and management of educational activities. The first phase focused on the verification of the square metres/students ratio, in compliance with distancing parameters, introducing variables such as space distribution and types of equipment, which resulted in the development of a compositional module that allows customising and optimising the set-up of classrooms while respecting the distancing parameters. The second phase concerned the assessment of the digital tools necessary for managing the space set-up process, reducing and optimising the required time-frame for providing the compositional layouts for every complex, while also determining the framework of the software programmes to be used and their degree of interoperability, in order to establish an information flow which would, in real time, prepare the articulation of classrooms and their access methods. The third phase regarded the possible developments of digital process management, indicating the potential use of data within the systems related to the booking, access and use of spaces by students.

### 3. Definition of the compositional module

The first research activity analysed the possible classroom set-ups in relation to the maximum number of students allowed to attend lessons in presence, in compliance with the distancing parameters indicated in the national references established by the Technical Scientific Committee (CTS), as well as with the directives of the University of Florence. To this end, regular square mesh grids with the side equal to the diameter, measured according to the allowable distance between the labial commissures (in other words from mouth to mouth) of the students, were superimposed onto the average standard classroom. The analysis of the square mesh grid highlighted the redundancy of unused spaces and the limited elasticity of the module, especially when distribution corridors, entrance-exit systems, and safety routes were introduced.

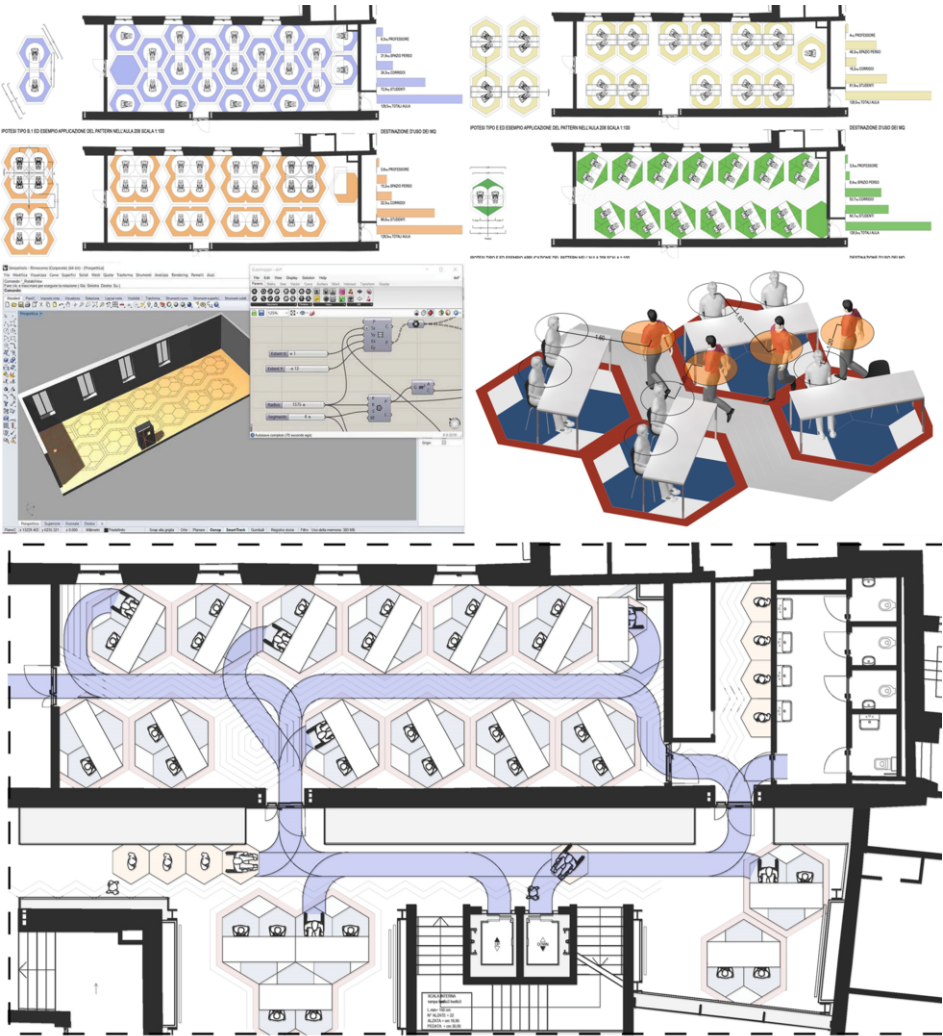


Figure 1. Design stages of the hexagonal base module.

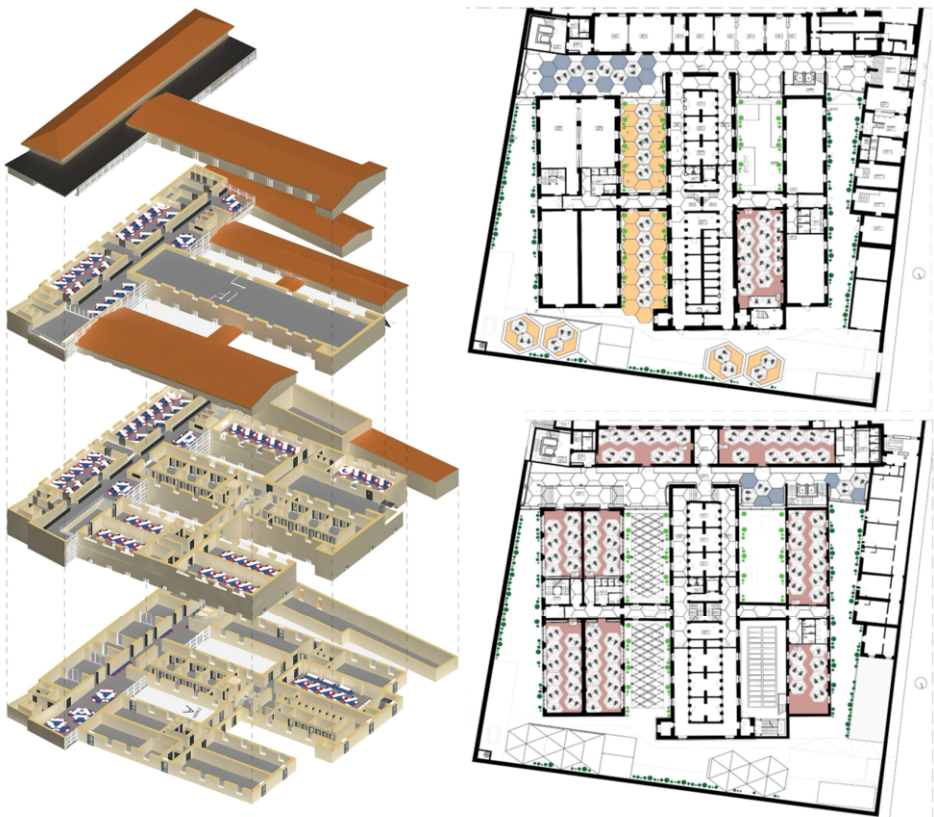
A notable decrease of unused spaces, both regarding the composition of the students' workspaces and the possible usable articulations based on the different geometric conformations of the classrooms, was obtained by applying the same dimensional parameters regarding the distance between students, yet setting the relevant circles on a hexagonal tessellation. It is on the basis of this pattern of reference that the variables relating to the types of furniture present have been inserted, as well as those regarding teaching methodologies, or rather the possible safe interaction between teachers and students. The purpose of this is to reduce as much as possible the need to purchase new equipment and to ensure the continuation of laboratory educational activities. The proposed solution is articulated into three central hexagons which determine the individual workspaces of the students (with an apothem of 0.6 metres), included within a macro-hexagon (with an apothem of 1.40 metres) that sets the perimeter of every study-group, thus ensuring a social distancing equal to 1 metre-radius both in the interaction between students and teachers and in the flows along the distribution corridors (in the 2D domain, as demonstrated by J.L. Lagrange, the highest-density reticular arrangement of circles is the hexagonal arrangement). This macro-hexagon can accommodate all the variables of furniture present in the Department's classrooms and permits, in addition to the traditional frontal configuration, an inclined set-up of the students' placements (with a 30° degree of inclination), which improves visual performance and favours visibility of the teacher's location.



Figure 2. Checking interior: student-teacher visual angles ; usability: movement spaces.

#### 4. Application to the Santa Teresa premises

As mentioned earlier, the solution was tested on the building of Santa Teresa, headquarters of DIDA. The building, which houses both educational and administrative functions, is articulated into two main blocks. The first is a historical building that originally accommodated ecclesiastical functions and which currently includes the offices of the Head of the Department, as well as some classrooms and laboratories. The second block is of recent construction and includes the main entrance and is primarily devoted to educational functions. Before the Covid pandemic the complex received an average of 1500 students per day, in addition to 50 other persons among teachers and administrative staff. In applying the different compositional modules to the teaching spaces involved in the case study, it was determined that by using the hexagonal-based module, a 15% increase of the available workspaces was obtained in comparison to the square-based module. This increase derives both from the optimisation of student spaces, and from the greater flexibility in the management of entry-exit paths set up in compliance with safety regulations. Furthermore, the possibility of using the module for the management of distribution corridors inside the building was tested in the context of the case study.



**Figure 3.** Setting up classrooms in the Santa Teresa complex. Modelling in a BIM environment.

In particular, a management plan for the flows involving both general connecting and service paths was determined through the analysis of the access points to the building, assuming staggered entry times, calculated on the average usage speed (about 0.8 m/s) and taking into account both the time needed to cover the distances and that which is necessary to carry out sanitation, identification and temperature measuring activities. In order to facilitate the management of paths and to indicate the proper use of spaces, a wayfinding project was developed proposing once again the hexagonal module as a design reference, with floor signage to be used both in the case of junctions (crossings) of the connective paths and in the setting-up of classrooms.

## **5. Determination of digital support systems for the management of the project and software interoperability**

With the aim of systematising the proposed procedure and to render it applicable to all contexts of the University of Florence, the following phase of the research involved the development of specific digital plug-ins capable of preparing, in Building Information Modeling, or BIM-ORIENTED environments, the design of the spaces while taking into account the typological-dimensional variables of the classrooms, the parameters relating to flexible distancing measures, the types of furniture and equipment and the different varieties of teaching – training modes. The decision to rely on BIM-ORIENTED systems was taken following the analysis of the digital environment used at the technical offices of the university. In particular, the technical department manages the complex through two-dimensional digital bases linked to a management system of the buildings which in turn is part of a Computer Aided Facility Management (CAFM) system. Beginning from the recent regulatory references regarding the digital management of design processes in public spaces, the first objective was to establish an information flow that would ensure the interoperability of data on open formats.

In other words, on formats capable of ensuring the processes of collection, storage, production and updating of information so as to facilitate Space Management activities. From an operational point of view, a series of BIM models of the Santa Teresa complex were produced. These models, modeled using both Revit and Archicad software, were developed beginning from two-dimensional bases and importing the information contents regarding the destination of use and the features of the installations managed through the previously mentioned CAFM systems used by the university (Infocad). The choice of using Revit and Archicad as modeling software falls both into their methodology of using interoperable formats as specified by Building-Smart-International (BSI-IFC), and their methods of allocating information with respect to environmental management tools (rooms and zones). Through (2x3) open formats based on International Foundation Class (IFC), the models were exported onto a geometric modeling software capable of interoperating with a parametric programming plug-in necessary for the management of the previously described tessellation project (Rhino + Grasshopper). The programming module made it possible to determine the algorithm that manages the production of the layouts related to the space arrangement solutions, using the hexagonal module and defining the solutions based on the variables considered, such as the positions of the doors or windows, or the dimensions of the furniture and equipment. In summary, we have programmed the rules of the composition based on the interpretation of information content specifically identified in the



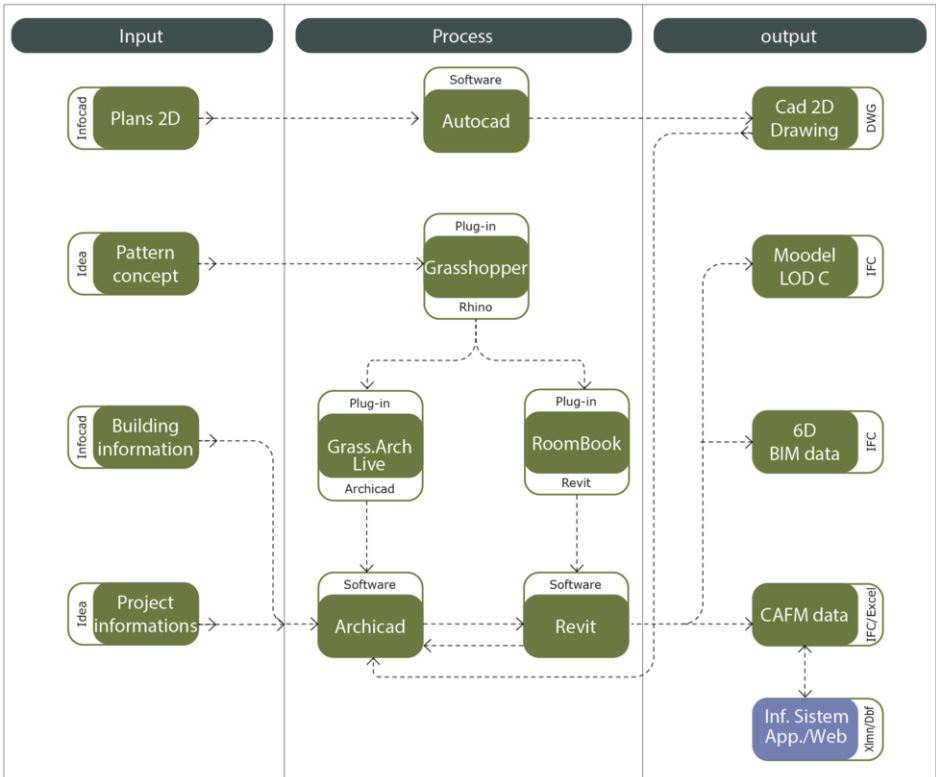
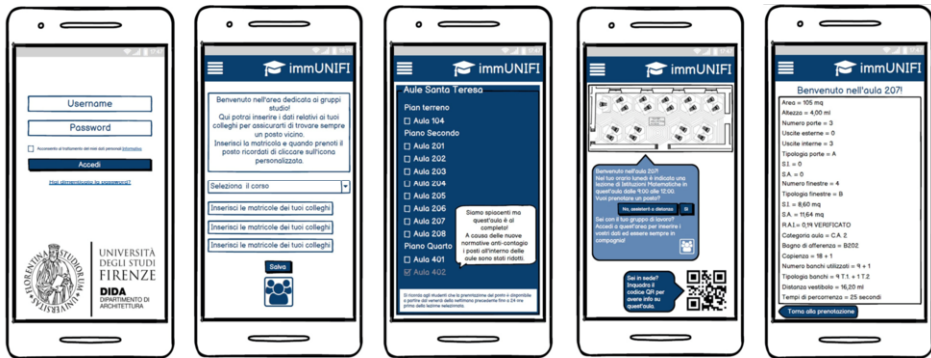


Figure 4. Information flowchart.

programming semantics of the BIM models. The possibility of managing the dimensional parameters of the compositional pattern through a programmable control allows for an agile updating of the layout, and therefore also facilitates the dynamic stages concerning the arrangement of spaces as dictated by the evolution of the emergency phases. The information concerning the layouts can be exported for subsequent processing and integration with other software programmes specifically designed for particular project-simulation activities, such as those relating to the management of installation systems or simulations of air changes, to mention some which are related to specific issues of the pandemic emergency. The information flow represents, in its articulation, a high level of complexity. The need to *surf* between different digital domains, in order to refine the information content of the model, denotes a management complexity that derives both from the characteristics of the software and from the need to adapt and allocate data in open domains. But it is also a demonstration of the potential of digital information management.



**Figure 5.** Design of an App. for reserving classrooms. Booking interface with user group verification

In order to demonstrate the potential of digital process management, at the conclusion of the research, and only in the form of a feasibility analysis, a space reservation system was designed for students which involves the identification of individual study stations. Digital tessellation permits identifying every single study station, relating it to a classroom and associating it to a unique identifier code. The information can be exported onto the CAFM database used by the university, and then published in specific existing web platforms accessible from any PC or smart device. The published data can be linked to a student space reservation system. Alternatively, the information can be managed by specific Apps which use and interact with space management software programmes, not only ensuring a proper method for the booking and occupation of spaces, but also tracking their use by students and teachers.

## 6. Conclusion

The experience described here has allowed us to identify a design path which, beyond the proposed compositional solution, identifies an operational procedure. A procedure that makes use of a methodology which correlates the functionalities of the software programmes in an information flow that is based on open formats, therefore available, adaptable and modifiable on different containers (buildings). The contribution aims to identify some of the potentialities of the digital management of built assets, which today has become increasingly important, also in terms of the dynamics regarding flexibility in the usage of spaces as related to transformations in the ways of using the said spaces. These dynamics must take into account the potentialities of the spaces so as to optimise decision-making processes. The experience, although limited and defined with open source digital applications or with licenses devoted exclusively to educational and research activities, can serve as the basis for the programming of specific plug-ins to be integrated with the main commercial software programmes, with the purpose of spreading the use of BIM-CAFM integrated systems also in the maintenance phases (6d), as specifically indicated in the recent calls for projects funded by the National Recovery and Resilience Plan (PNRR).

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