4. L: Space and technology as facilitators of new hybrid learning experiences: the Politecnico di Milano's Innovative Classroom Project

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Abstract

The future of design teaching is increasingly being faced with new reflections and challenges in the field due to the evolution of users' needs as well as new and updated learning models. Furthermore, the effectiveness of universities is based on the balance of three main essential elements: pedagogy, space, and technology. However, the growing use of new teaching practices necessitates a serious consideration on the design of learning spaces in universities and colleges. Nowadays, existing spaces are generally unsuitable and ineffective in supporting the progress of an educational path based on the comprehensive use of ICTs and digital supports. This lack of appropriate spaces must foster the revision of university environments – classrooms, laboratories, and connective spaces – in terms of flexibility, personalization, and collaboration, creating an envelope designed to support and encourage the different learning practices. This chapter discusses the design and development of four pilot projects for innovative classrooms; four spatial applications to experiment and involve all the users in a participated implementation of the new requirements across all the disciplines of the university (engineering, architecture, and design). They were realized as part of a more extensive innovation programme of the Politecnico di Milano, and they involved different dimensional scales. The space of the innovative classrooms is spreading across the campus through a fluid multi-scalarity that connects interstitial spaces to shared spaces favouring social and active learning approaches through the use of technologies.

The higher education system has undergone numerous changes over the last few decades, many of which have been accelerated by the COVID-19 pandemic. These included moving away from a traditional university learning environment characterized by fixed and predefined infrastructures, and moving towards a new framework of a more flexible space designed according to new user needs.

Consequently, universities, like any other social organisms, have had to implement massive organizational, pedagogical and spatial evolution, shaping themselves according to contextual transformation. According to De Ridder-Symoens (1992), universities have formed the new academic layer, changing the entire structure of society, enriching it, making it increasingly complex, and creating an ever-changing virtuous circle.

What universities are seldom able to transfer to their students today is the ability to deal with the challenges that most work environments present, such as the flexibility to handle multiple issues at once and the ability to develop soft skills and transversal competences (Morrell, 2012). This is often due to the university structure, which is still significantly anchored to the past in many aspects. University training programmes must be able to convey to students a skill set consisting not only of a solid technical and theoretical preparation, but also of a dynamic combination of cognitive and metacognitive, interpersonal, intellectual, and practical skills (Haselberger *et al.*, 2012). Crucial transition towards more personalized, social, open, and dynamic learning models is required, which can be stimulated by the design of innovative spaces (Chatti *et al.*, 2010).

A learning environment is made up of various factors that influence learning (Warger & Dobbin, 2009) in which objectives and design cannot predict everything that happens; some aspects elude control or are, at the very least, unplanned. The environment, then, is a combination of planned and unplanned events, a mix of the intentional and the unintended. Users create positive encounters and "clashes" in order to interact and satisfy their learning needs.

The effectiveness of universities' innovative learning spaces is determined by the balance of three key elements that can be designed: pedagogy, space, and technology (PST) (Radcliffe *et al.*, 2008). These primary components form a complex organism suitable for the development of fresh, capable, and complete individuals who are able to handle

the challenges of a future society. However, factors such as technological advancement, generational renewal, and new economic systems are urging a faster evolution of today's society. As a result, even today's higher education is becoming increasingly ineffective at its primary task of transferring knowledge to future generations (Zanolin, 2017), necessitates a massive and ongoing update to keep up with the mutable surrounding reality.

It is crucial in the field of university education to keep up with technological innovations that are continually take root in contemporary social structure. The advent of technologies and the birth of the World Wide Web in the last decade of the twentieth century triggered an unprecedented process of change in everyday life. In the context of universities, and education in general, technology has succeeded in providing a series of digital devices for its own use, in addition to expanding the concept of space towards the creation of a virtual environment with endless possibilities of use. To build an effective training offer based on increasingly pervasive Information and Communication Technologies (ICTs), education must be calibrated with the tools provided by ICTs' offer based on increasingly pervasive connectivity (Morrel, 2012).

Classroom environments must engage in connections on multiple levels, creating and encouraging both real and virtual experiences using smart devices and immersive solutions.

New learning models

In recent years, we have experienced the evolution of learning models that can be adapted to new generations of students born and raised in a highly digital environment. In terms of pedagogy, technologies can be identified as a supportive tool for the development and simplification of all the activities that occur between different actors in campus spaces. First, it is necessary to visualize an adaptive curve that has redefined the roles of teacher and students over the last century.

This transition has prompted the creation of new learning models based on the active teaching method, which is defined as "*a method of learning in which students are actively or experientially involved in the learning process and where there are different levels of active learning,*

depending on student involvement" (Bonwell & Eison, 1991). The inclusion of this approach, which is much more engaging than a passive model, has shaped the traditional lesson into an educational opportunity based on the sharing of experiences and personal maturation.

Students are guided into a more self-directed path in which they can build technical and logical skills in a variety of circumstances with and without the assistance of others (Milrad *et al.*, 2013). Active learning paradigms, such as participative and cooperative learning, enable the acquisition of knowledge and personal skills through problem-solving, discussion, and cooperation among small groups of individual students, as well as contact with online communities, teachers, and experts. It is feasible to reach a broader and more effective level of maturation and growth by combining more involved activity with the use of increasingly high-performance digital equipment.

Active learning, defined as has been able to alleviate the difficulty of exchanging knowledge between teachers and students by promoting an effective type of learning for the latter that is aimed at a greater implementation of personal skills and communication abilities. The combination of these two types of learning results in a blended model in which the traditional relationship between teaching and learning, as well as the degree of relationship between teacher and student, is challenged by a didactic path that winds through both passive and active knowledge exchange (Maglioni & Biscaro, 2014). This hybridization of the learning system is emerging as a more effective innovation than the passive one at all levels of education (Christensen *et al.*, 2013).

The increasing importance of technology in everyday life has necessitated an essential overhaul of the entire learning system, making it much more dynamic and integrating a significant number of useful tools and virtual layers. This new type of education, which can be collective or individual, is defined by the concept of seamless learning, which is the ability to extend learning across time and space, to access physical and digital worlds, and to use multiple types of devices to integrate different approaches to teaching and learning (Sharples *et al.*, 2014).

Furthermore, a collection of behaviours and human interactions encouraged through the use of technology might initiate a rethinking of the effectiveness of today's learning systems, thereby delineating a reflection on the shape and usage of places. Similarly, regardless of its intended use, an environment can affect people's behaviours

(and hence teaching and learning models) that tend to manifest in it (Radcliffe *et al.*, 2009).

New generations of students, born and matured in the digital era, will soon begin an educational journey inside one of the numerous university educational offerings. Future university campus users, who have grown up with smartphones, social media, and virtual worlds, will demand the university experience to resemble the web's "connected in real time" character. As a result, the future of university education will necessitate a greater emphasis on the figure of the learner, as well as enhanced interactive, immersive, and social activities among users. To address these issues, it is critical to begin rethinking the university environment, attempting to make it more dynamic and adaptable, constantly ready to follow and stimulate students by providing constant access.

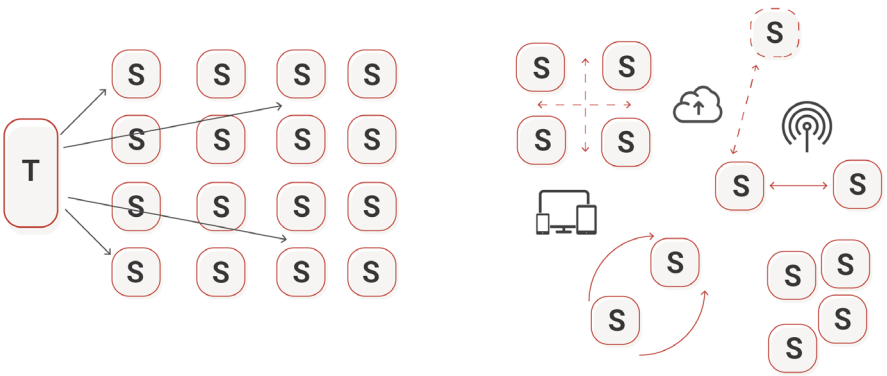

Fig. 1 – A comparison between the previous learning environment and the current needs

These factors are having an impact on the entire structure of learning spaces, which are no longer conceived as a centralizing place for individuals but as a facilitator of sharing and deepening of disciplines: a place for learning that becomes the fulcrum of interaction between students.

The dynamic confluence of space and occupancy as social and spatial practices is used to investigate space and its occupation. Rather than restricting students to a passive experience, we must investigate ways to fully involve them in learning activities.

New models of learning spaces

With the rise of education that is mostly based on the development of group projects, the demand for larger, hybrid, and flexible environments that allow for active and collaborative learning becomes apparent. Conventional classrooms and libraries are no longer able to sustain new teaching approaches due to architectural constraints imposed by the previous historical context.

All the spaces designed for other kinds of functions – such as cafeterias, bars, and green areas, as well as all the connective and transit fabric – appear to be more equipped to intercepting the changes imposed by innovative technology learning resources.

Currently, most of the time spent studying and learning takes place outside the classroom, in informal external places where new modes of cooperation are possible, due to both tech devices and the consequent redesign of the classical concept of space.

It's remarkable to see how the huge growth in hybrid space users, a result of the novel idea of activity-based working (ABW), is made possible by computers and tablets. This function is evolving as a nomadic type of activity that does not require traditional spaces designed for a specific activity, but rather hybrid environments that provide individual spaces and shared infrastructures to which all users have quick and easy access. In the activity-based context, the single user chooses the best position to work from based on his/her needs and requirements: the space is subordinated to the activity because it can potentially be applied everywhere.

University campuses are no longer conceived as a series of "educational" buildings, but as a holistic collection of spaces, each having the potential to contribute to the educational impact. They must be defined as "*a complete network of connected learning environments […] where the learning process does not exist individually but takes place within a range of different types of pedagogy, spaces and technologies*" (Radcliffe, 2008).

University campuses are complex organisms with poorly defined interstitial regions between learning and connection spaces. All circulation areas, both inside and outside buildings, must be redesigned to maximize their inherent potential. The construction of corridors equipped for both individual and teamwork can be part of a

strategy aimed at establishing a continuous network of information exchange: the design of these spaces can generate different activities enhancing social relationships. "*Learning happens everywhere, not only in classrooms and libraries, but in corridors, social structures and walkways, courtyards and squares between buildings. Even the academic space as an end in itself is disappearing. There is still room for traditional classrooms, but they too can be remodelled to meet other needs*" (Chatterton, 2000).

The informal space establishes a different relationship between students, and between students and teachers, resulting in a different interaction than that established within a formal educational space. The relevance of students learning together in a collaborative way is often underestimated (Bickford & Wright, 2006), disregarding how much the context can influence interpersonal interactions. The (forced or self-imposed) norms that students and teachers must follow in the formal environment tend to decrease in the informal space, enhancing synergies that boost learning potential.

This concept of being free of regulations is related to the "third place" idea proposed by Oldenburg and Brissett (1982), which is "*a public setting accessible to its inhabitants and approached as their own*" (Hunter & Cox, 2014).

Furthermore, in a community where internet interactions naturally homogenize connections, the informal space encourages unplanned and unexpected contacts, which are essential for democracy and personal growth.

Bennett (2007) identifies other criteria for successful learning environments, including the ability to distinguish between socializing and studying; to enable choice and flexibility in uses; to allow for territorial claims; and to build a sense of community. As a result, the physical qualities of the informal study areas are crucial.

All parts of a campus must become more appealing and provide opportunities to make full and personal use of the available spaces.

These areas must be more equipped, more pleasant, and more productive. It will be crucial to provide the campus with the resources required to animate all the interstitial spaces, thereby establishing small- and medium-sized workstations.

Informal spaces also have other positive consequences on the university system, such as improving students' sense of belonging to the institution through the experience of space (Morieson *et al*., 2018).

An important benefit is the rise in reputation because of physical evidence provided by tangible parts of the learning experience, through the impression generated by the space. Enache (2011), quoting Ivy (2008), alludes to the 7 P's of educational marketing (product, price, placement, promotion, people, process and physical evidence). The last, physical evidence, considers all the tangible features of the place that represent the quality of the services that can be physically experienced, as well as all the physical evidence that contributes to making a positive impression on the user. It is accountable for the tangible meaning of the educational product and the reputation of an institution because it is the strategy that has the greatest impact on the sensory aspects of the space.

A pleasant learning environment must therefore be created through the active occupation of the space and the furniture. Users are deeply engaged in the creation of learning environments since learning is a social activity. Interior design, furniture, colours, signs, and social conventions all contribute to the construction of such environments that designers conceive and build, but users actively use, to create the diverse situations in which informal learning occurs (Cox, 2018).

Informal learning spaces become fundamental in this scenario for creating collaborative learning methodologies. Through conversation, engagement, and collaboration, students can create a pleasant atmosphere in which to expand their knowledge and strengthen their community (Jamieson, 2003). Informal spaces, such as learning corridors, must be built in tandem with formal learning spaces, such as classrooms. The collaboration of these two types of spaces can result in complex and resilient learning environments that can fulfil each institution's goal of facilitating the student (Oblinger, 2005). The formal classroom extends outside its walls, not only through technology, but also through the design and furnishings that create comfortable and productive informal places.

Learning spaces and technology

While technology integration has long been a major topic in education, the convergence with the quickly changing educational landscape is shaping education in deep, new ways, according to Groff

(2014). Emerging technologies are forcing a rethinking of teaching and learning, as well as acting as catalysts for transformation and innovation.

When we look at the intersection of pedagogy, space, and technology, we see what is known as "Next Generation Learning Spaces" (NGLS) or "Future Learning Spaces" (FLS), where the three elements create the conditions for social, collaborative, and active learning, and where the use of digital and technological tools (as a support for the various activities) can allow the creation of different creative places within the same space (Lippman, 2013).

The relationship between the space itself and the activity carried out by teachers and students through the use of technology must be considered while designing an innovative and technology-enriched learning space.

Technology may help users in facilitating learning dynamics; improving space comfort (for example, through sensors that enhance the quality of sound, light, and perceived temperature); extending space limits (for example, using immersive technologies that create virtual environments); and maximizing space usage (through the right devices for the requested task to exploit the areas in the desired ways).

Space can assist technology users in enabling convergence between various systems, discovering new applications, developing new kinds of interaction, and improving the "state of the art" of a technological tool.

We are evolving towards a more mixed, blended, virtual and real educational environments that are also more interactive, because the experiential dimension provided by person-to-person and person-to-machine interaction often makes multimedia learning environments effective.

One of the most difficult issues when employing technology to help education in a learning setting is users' ability to approach technological devices naturally and without any psychological barriers.

If we consider every one of the components, the future technology-enhanced learning space should allow for many techniques and uses, limited only by user imagination (architecture, furniture, and technology). The spaces must include "casual" and supportive technology that is not physically intrusive and does not obstruct the regular flow of creative work.

The affordance concept developed by Gibson (1977) and Norman (1988) is applied here. The affordances method is ideal for a technological learning environment because it focuses on the interplay between information and communication technology infrastructure and people's usage of those technologies (Conole, 2004). The interaction between individuals and technology, as well as their creative and varied collaboration with the learning environment, is prioritized over any consistent reaction to any specific elements of that space.

The educational space should then be designed in a way that the presence of devices is completely integrated with it, so that students, when engaged in using the available technological tool to interact with teachers' contents or requests, are able to operate and communicate their intentions and results naturally and without difficulty. All technology instruments and equipment are merged with the traditional space in the best possible design of learning settings, creating the circumstances for open and unrestricted interaction between teacher and students and between students and peers.

As a result, we can confirm that in an evolved setting, the digital and analogical worlds must collide to create new methodologies. An educational system does not refer to a enforced technological field (technology as an end in itself), but rather to one in which technology is one of the elements that contribute to the development of positive learning dynamics.

The learning environment connects the material and immaterial aspects of identity construction, enabling critical and constructive learning through debate and engagement (Wheeler, 2009).

As a result, technology must be explained in connection with its application (space) and the activity that employs it (pedagogy). As stated before, Radcliffe (2009) created the PST framework, which connects pedagogy, environment, and technology. It extends Oblinger's research by providing a model that integrates technology, space, and pedagogy.

It is a question-driven inquiry process that empowers a wide variety of potential stakeholders to analyze and holistically consider the pedagogical, technological, and physical aspects of teaching and learning spaces and their interactions. The innovation properties (Manciaracina, 2019) associated with the three framework elements were considered for the research effort that is the focus of this study.

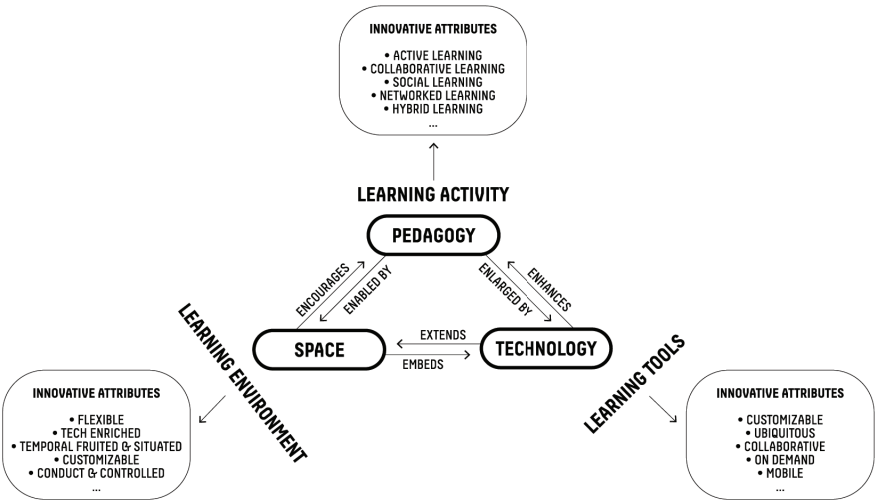

Fig. 2 – PST Framework, edited from Radcliffe et al., 2009

The implementation of technology must be guided by an evaluation of the kinds of activities and people using the space. On the one hand, it is critical to explore the types of interactions that occur between students and educators; on the other, it is necessary to assess the influence that technology can have on the relationship system, both offline and online.

Two key didactic actions can be identified.

First, a teacher-led activity that may be defined using four distinct poles:

- conventional (frontal) didactic activity in which the professor disseminates knowledge to students;
- collaborative pedagogic activity in which the teacher includes students in knowledge-building;
- offline technology;
- online technology.

Second, students engaged in an activity that may be defined using four different poles:

- action in which students exhibit the results to teachers and peers, or only to peers;
- collaborative activity in which students work together to develop knowledge;

- offline technology;
- online technology.

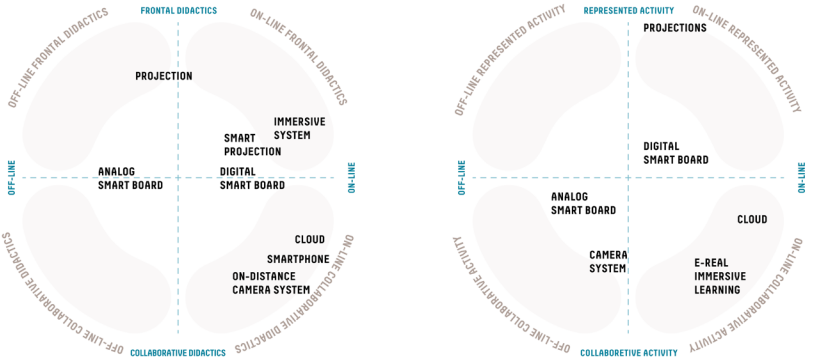

Fig. 3 – Diagram of the technologies dealing with the space and the people's actions

The technology employed in educational environments must thus migrate from a vertical technology, designed to satisfy the demands of teachers in a limited setting, to a horizontal technology, designed to suit students' personal needs across different physical contexts (Fig. 4) (Stroup & Petrosino, 2003). Students can employ technology to design their own personal way of creating knowledge and learning outcomes to achieve the intended learning objectives.

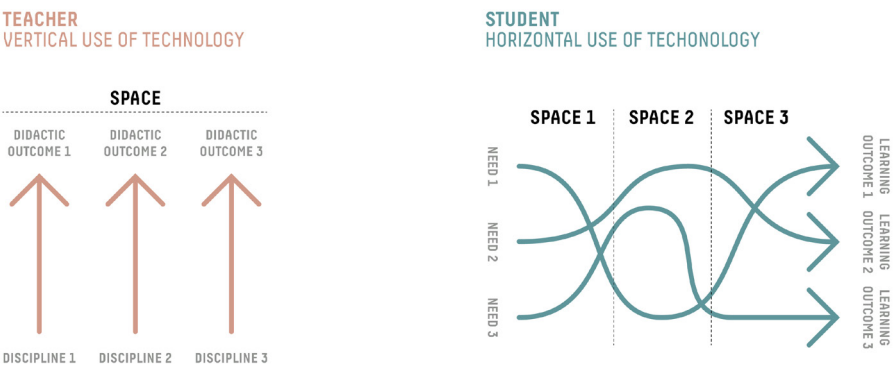

Fig. 4 – Vertical and horizontal uses of technology

The case study of the Politecnico di Milano

Throughout the design process, it is critical to begin rethinking higher education facilities wich use practical prototype experience. A significant challenge has evolved from the Politecnico di Milano's current and future intentions, outlining a general programme with these key aims over three years (2018-2021) to answer new contemporary demands on the issue by building various prototypes of innovative university classrooms. It is an in-depth review of its spaces to better understand the needs of all university users and to anticipate new situations that might support developing teaching and educational approaches.

A research team from the Politecnico di Milano has been tasked with defining a set of requirements and needs for the overall organization of the innovative teaching and learning spaces to achieve these goals (Collina *et al.*, 2019). The team has been asked to give an overview on spatial demands, potentialities, new habits, and applications, as well as arranging all spatial requirements into guidelines that will be applied first to the 4 classroom prototypes and then disseminated for large-scale implementation. These are four experimental spatial applications involving all users in a participatory process defining new criteria, including all the university disciplines that are taught at the Politecnico di Milano (engineering, architecture, and design).

Rethinking educational environments requires being aware of changing needs, trends, and other elements that influence how students interact with the university environment. The goal of the research was to analyze these new needs from the standpoint of spatial and service requirements, while considering new habits and educational approaches that all stakeholders face in these spaces. To achieve this objective, the Rector has asked the research team to provide guidelines for the development of classrooms dedicated to innovative teaching. As it has been determined to adopt a user-centred strategy, categories of study participants have been created to incorporate them in the research process (Fig. 5).

They can be classified into four categories:

- internal actors with experience in teaching activities;
- internal actors with experience in innovative teaching;

- internal actors responsible for the maintenance of teaching spaces; and
- external actors with expertise in technology relevant to the context

As previously indicated, the project focuses on the development of four distinct learning environments in three main disciplinary contexts. The primary step was to analyze the various styles of teaching in schools in order to find macro-areas of intervention on space (i.e., the disciplines of design and architecture require a more similar distribution and type of instrumentation than engineering). To gather as much information as possible, the research team analyzed numerous learning behaviours implemented in several fields with the assistance of teaching professionals.

The second step was the acquisition of the state of the art of the research, also through the evaluation of case studies of contemporary campus projects; the definition of requirements for the design of innovative teaching activities, with reference to the most advanced learning tools; the development of specific guidelines for use and dissemination within educational environments; the implementation of strategic partnerships with the educational sector and industry for relevant social intervention.

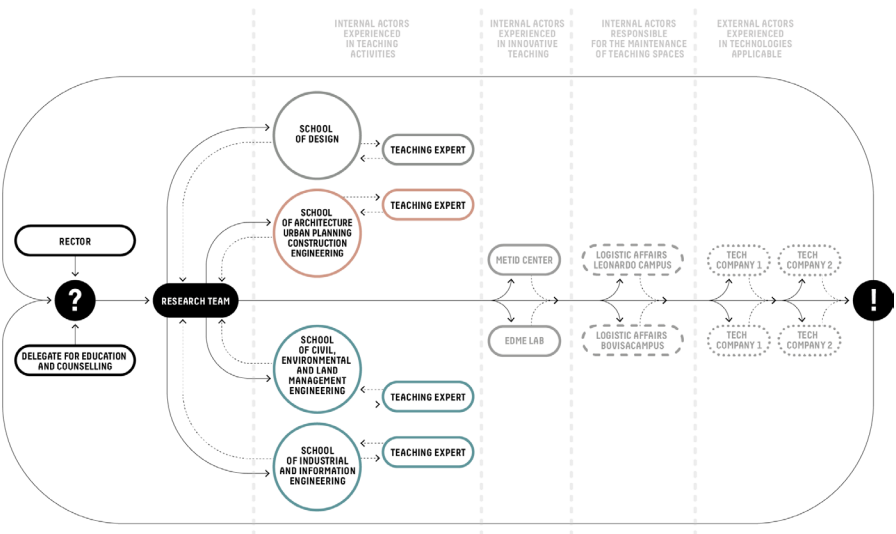

Fig. 5 – Map of the actors involved in the research process

A next step was to meet the centres already present in Politecnico di Milano spaces that are working with didactic interaction developed by employing technological innovations, which: the METID centre, which has set up a room specially designed to test the use of technology in innovative teaching; and the interdepartmental laboratory EDME (Environmental Design and Multisensory Experience), which provides a physical space to develop and undergo digital, multimedia and multisensory worlds.

Through these two experiments, it was possible to deal with new learning technologies such as large-scale digital smartboards and analogue smartboards capable of sharing written information in the cloud, or immersive digital theatres where the user can create a teaching experience inside a specially created virtual set that transforms a room's walls into touch and interactive surfaces.

After gathering information to better analyze the context, the logistical offices in charge of maintenance were involved in deciding on the sorts of intervention appropriate to the spaces in terms of proportion, light and sound management, position in relation to access flows, and connection spaces. Meanwhile, technological equipment was

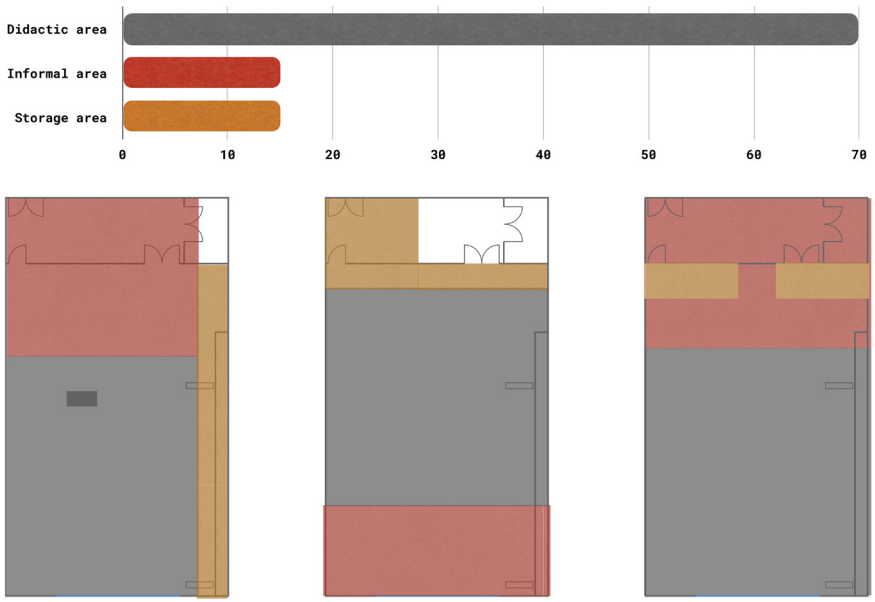

Fig. 6 – Configuration element and sample of application

investigated to enhance active learning behaviours and allow instructional activities dedicated to smart information interchange and online dialogues between students and remote lecturers. The approach concluded with a dedicated meeting to relate the research conducted to recalibrate the interventions and reformulate research and design suggestions for future activities.

Grammar of Directions (GoD)

Starting with the prior considerations, a common language has been defined to organize all the elements identified. A grammar of directions (GoD) has been created to define a common basis for the emerging disciplines' spaces as well as to validate the forms of intervention required to raise the space to an innovative and flexible state. A system has been adopted to interweave the different spatial components with the possible degrees of intervention to allow the development of a basal matrix that may be updated with possible optimization interventions for the different disciplines' peculiar activities. The intended environment must be flexible enough to support various forms of teaching and, as a result, be ready to change itself as needed.

GRAMMAR RULES	BUILDING	FURNITURE	TECHNOLOGY
BASE LEVEL	• ACCESSIBILITY • LIGHTING • DARKENING • ACOUSTICS • ENVIRONMENTAL COMFORT	• FURNITURE ACCORDING TO THE NORM • SOCKETS	• WIFI • PROJECTION • SOUND SYSTEM • WIRING
INTERMEDIATE LEVEL	• FLOATING FLOOR • ELECTRICAL SYSTEM • SOUND-ABSORBING PANELS	• MODULAR FURNITURE • WRITABLE WALLS • MOVABLE SOCKETS	• VIDEO SYSTEM • ADJUSTABLE SOUND SYSTEM • MULTI PROJECTION • SMART BOARD • CLOUD + WI-FI
ADVANCED LEVEL	• FLEXIBLE STORAGE SPACE • WALLS EQUIPPED FOR DISPLAY • MOVABLE WALLS	• TRANSFORMABLE FURNITURE • FOLDING FORNITURE • INDUCTION/WIRELESS SOCKETS	• IMMERSIVE CLASSROOM • DISTANCE COMMUNICATION TECHNOLOGY • CAMCORDERS • VIDEO MAPPING PROJECTON

Fig. 7 – Grammar of Directions scheme

To identify the forms of intervention required, three sets of physical and virtual features and components with significantly different impacts were identified:

- Building: The framework of the space is made up of systems and surfaces that will better support any activity that will take place in the classroom.
- Furniture: Flexible furnishing components that allow for fast changes of the layout based on teaching needs.
- Technology: Anything related to the virtual appearance and digital devices used to enhance the teaching experience.

The three groups comprise all the supporting components required for an effective teaching path. However, since the space must accommodate different kinds of activities in addition to the conventional ones, changes must be made through implementation and installation of resources. Three intervention phases have been identified to raise the physical space of the teaching from a basic conformation to a more sophisticated level:

- Base: the starting point that incorporates all the elements required to ensure fundamental support for the delivery of a traditional lesson, such as moments of exchange between professor and students (lectures, feedback sessions, seminars), as well as peer-to-peer activities to be performed in groups. The furniture must be chosen in accordance with the regulations, and the system must allow for soundproofing, classroom darkening, and a digital apparatus adequate for providing the simple execution of audio/visual material as well as a high-performance wi-fi connection.
- Intermediate: all the changes made to the class are performative, offering a greater degree of flexibility to allow a quick reconfiguration of the classroom. The furniture, which is moveable, modular, and writeable, is supported by a more flexible technology baggage, which includes smart boards, cloud platforms, and multi projections.
- Advanced: to diversify a single space depending on the special needs of each course, an even greater degree of optimization and improvement is required. To enable the execution of some extra activities, it is necessary to consider a flexible storage system to store the furniture in order to entirely free up the environment, as well as a system of moveable walls to expand the space.

The furniture must be comfortable but foldable in order to be quickly moved and stowed, while the digital equipment must allow for a high level of immersion through the installation of multi-cameras capable of changing the perception of the classroom and enhancing the learning experience The use of this grammar, which arises from the basic needs related to the behaviours found in the learning spaces, is useful for planning a laboratory environment that can be implemented gradually. Understanding the common needs and the individual requirements helps to establish a hierarchy of interventions to be planned immediately to prevent the space becoming unable to support the teaching of the present and the future.

Relationship between classrooms – the elements

The research allowed for the creation of schemes that favour the choice of elements according to the educational experience chosen, implementing the experience and the action to be carried out with the characteristics useful for this result. Through the diagrams, the relationship between space and technology is described in more detail, analyzing the types of activities and actors using the space.

To demonstrate how this diagram may be used to generate new scenarios, three options for space arrangement will be provided, and each follows the previous phases of the guidelines.

A – Virtual frontal didactic: a frontal type that permits 360-degree use, with two opposing projected walls that allow you to keep a position that stimulates cooperation in periods of active learning and sharing with colleagues. Frontal instruction is also virtual in this instance, and due to the established supports, it is possible to attend a session held at the same time in a class abroad. It is also feasible to see how the informal area outside the classroom encourages the use of space for actions and user engagement.

B – Classroom activities: In this scenario, the furnishings stimulate interaction and allow for fast reconfiguration of the classroom to facilitate cooperation. Moving dividers in the support storage area allow for the preparation of tools for group work in open space. The surrounding walls can all be used for sketching and/or collaborating.

C – Collaboration activities: A part of the classroom has been created to allow full participation in the work review activity, even from a distance. A camera is put above the table to display the material that has been laid out, while a second camera can show the faces of the individuals around the table. The interlocutors may be seen from a distance on the other wall.

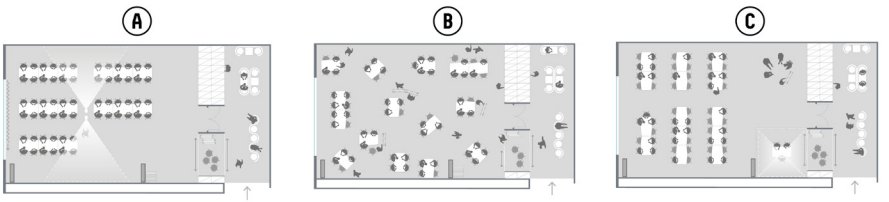

Fig. 8 – Drawings showing three possibilities of configuration of the space

This method of intervention was chosen to generate and accentuate the types of interactions that might occur between learners and their teachers in hybrid and connected environments. The informal configuration of space, as well as its status as a link place between the spheres of learning and leisure, encourages interaction between users with radically different roles, democratizing the student-teacher relationship. The space can be utilized to carry out all the revision or explanation activities that exist in the teacher-student relationship but struggle to materialize in a defined place.

The innovative classrooms realized and visible in the picture (Fig. 9) held the necessary flexibility requirements to allow the application of active pedagogies. Variations have been made in the type and position of the elements, in relation to the subject area in which they are 'dropped' while maintaining a sufficient degree of transversality to allow all users to use them profitably. In all cases, great emphasis was

Fig. 9 – Politecnico's innovative classroom

placed on aspects such as visual and acoustic comfort, ease in the classroom setting, and the provision of surfaces for collaborative learning.

Student-student relationship in informal spaces – interdisciplinary content

The informal environment is typically utilized by students for both studying and destressing, in addition to offering an excellent location for dialogue between lecturer and student(s). University campus connection areas are rapidly developing as venues for continuous contact among students who find themselves in groups to conduct both academic and informal activities. Interactions between user groups might benefit people by fostering the interchange of theoretical knowledge and methodological skills. These informal spaces comprise a wide range of non-conventional venues (such as cafeterias or student residences) where information is transferred via the study and cooperation of students based on cooperative learning (Neuman, 2013).

If outfitted with a variety of furniture and technology, the informal and connecting spaces may be turned into true multidisciplinary places where students can engage in an assortment of activities. The informal area must, in reality, provide suitable furnishings for the different activities to be carried out: seats, armchairs, pods, electrical plugs, tables, whiteboards, and others must be flexible and practical, allowing for quick reconfiguration of the space.

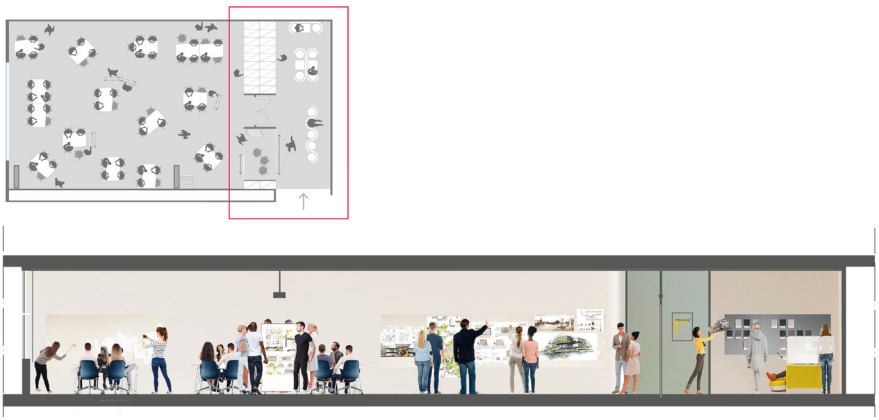

Fig. 10 – Contemporary presence of the didactic and informal area

Fig. 11 – Scenario of different activities in the same location

The process of designing informal spaces began with mapping out potential areas of intervention on the Politecnico campuses in Milan, which allowed for the identification of three major categories of in-between spaces close to classrooms that were only used as transit areas: dead-end corridors, linear corridors, and squares.

The following phase was to develop a list of modular solutions that might suit the users' various needs: solitary study, group work, and social interchange. In terms of seating, three macro-categories have been identified: tiered seats, pods, and benches. After that, a grid was built to connect spaces, functions, and solutions in order to provide three design concepts for the Leonardo, La Masa, and Durando campuses (Fig. 12). The Leonardo area is designed as a dead-end hallway where the tiered seating arrangement was installed. Because it

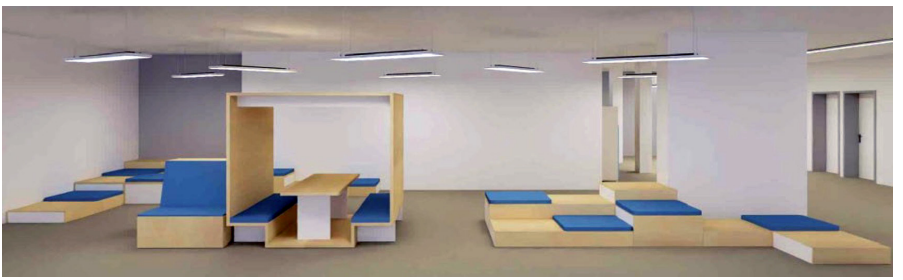

Fig. 12 – The elements that define the space on the Durando Campus

is not a tunnel, it was feasible to design a space with cabled steps that could, if required, become an appendix of the classroom, confronting a flexible display system for displaying the students' projects (Fig. 13).

Fig. 13 – Before and after the installation of the informal space on the Leonardo Campus

A modular system was evaluated and its adaptation to varied contexts was authorized in the La Masa and Durando Campus concept. In the first scenario, along a linear corridor with a central spine where plant cabinets alternate with underutilized regions where the various modules have been put, provides a common area with steps and places for group work (Figs. 14, 15). Individual study pods are positioned on the opposite wall of the central spine.

Instead, on the Durando campus, a plaza was chosen, which has been turned into an articulated landscape of the various module types owing to the placement of the modules The idea was enhanced with wall features such as analogue blackboards and monitors that students may connect to their devices in order to showcase their work. All of the areas include electrical and data outlets, as well as wi-fi, to facilitate cooperation, even with students from different campuses or abroad on exchange, as in the case of Erasmus programmes.

Because of the coordinated image research in connection with the innovative classrooms project, the materials employed have a formal aesthetic value, making the spaces instantly recognized, even if they are distributed throughout the many campuses. Students recognize the environment as a location for informal learning, resulting in distinctive

visual meanings. In Leonardo's platform, wood is coated with linoleum and blended with light blue-grey pieces that are the same colours as the classrooms, forming a sound-absorbing feature to improve the acoustics and comfort of the spaces.

The lights are renewed to offer diffuse lighting using the same language – the linear one – but scaled down to fit the space in which it is placed. The pods, on the other hand, have their own illumination to ensure an adequate level of illumination.

Particular attention is paid to the acoustic aspect in the spaces of La Masa and Durando, which are located in core portions of the campus, with comfort ensured by the installation of sound-absorbing slats or hanging panels.

The pieces that comprise the learning corridors may be utilized freely, providing for greater flexibility and an increased impression of informal space.

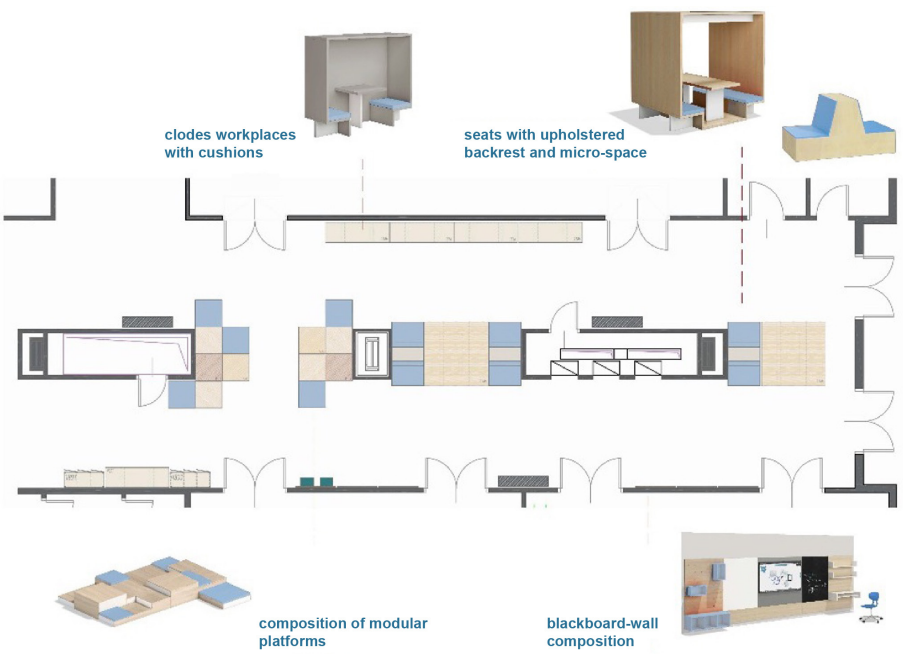

Fig. 14 – The layout of the abacus elements inserted in the La Masa Campus

Fig. 15 – Before and after installing the informal space in the La Masa Campus

Fig. 16 – The informal learning space in the Durando Campus

Conclusions

The experimentation currently underway at the Politecnico di Milano aims to be the first step in validating the various levels of integration between space and technology, analogical and digital tools, didactics in presence, and virtual collaboration, analyzing the possible interactions, interpenetration, and overlap between different methods and tools for teaching in order to achieve a consolidated and regulated omnichannel approach.

The new classrooms and learning corridors are a prototype that will be evaluated during the coming academic years in order to more deeply and better understand the potentialities of the numerous solutions that may be implemented. These solutions, depending on

the type of teaching and learning activities used in the educational journey, will provide a more flexible and inventive approach to didactics. Monitoring the behaviours and uses of the many players engaged will allow us to determine which solutions may be better adopted in the future, indicating which type to implement in order to respond to changing needs.

The results collected thus far demonstrate how it is feasible to envision an evolution of the teaching environment in which analogical and digital, physical and intangible features contribute to the improvement of interactions between the many players participating in the teaching process.

The concept of education is being expanded as an act that can occur anywhere and at any time (Oblinger & Oblinger, 2005), and new learning dynamics lead to the definition of spaces intended for formal learning, such as classrooms or laboratories, for a planned didactic conveyed through the traditional teacher's lesson. Informal spaces, on the other hand, include a broad spectrum of locations where information is exchanged via the study and collaboration of students or researchers.

These locations are positioned in "the space between", or in places with a high degree of architectural flexibility, allowing the discovery of new environments dedicated to group study and acting as a filter between the many roles on campus.

The anticipated outcomes seek to reimagine the spatial model that may support the learning environment within this continuous mechanism of interaction between people and place, in order to develop new forms of engagement, cooperation, and multidisciplinarity for the campus's future growth.

The development of group project-based education highlights the need for diffuse, hybrid, and adaptive settings that promote active and collaborative learning. Traditional classrooms are no longer sufficient to meet current teaching approaches. As a result, university campuses should not be considered as a series of instructional structures or units, but rather as an integrated synthesis of environments that may all contribute to educational value. They should be defined as a full network of interconnected learning environments in which learning takes place across a range of pedagogies, places, and technology rather than in isolation.

Additionally, the most time is spent studying, and learning occurs in informal areas outside of the classroom, where new kinds of cooperation might emerge.

The hybridization with other service functions targeted at enhancing and promoting the use of informal spaces, such as break places, books and materials sharing, and so on, will be examined in the holistic vision of future applications. Canteens, cafeterias, and green spaces, for example, appear to be more adapted to welcome the changes brought about by new learning needs and the new technology devices used by the next generation of students. Only in this manner will it be feasible to establish inviting areas not only within a certain building but throughout the campus.

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