Breaking Down the Silos

A Hypothesis for Redesigning the Academic Spatial Environment to Encourage Interdisciplinary Collaborations

POLITECNICO DI TORINO

Master of Science in Architecture For Sustainability

Master's Thesis

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A Hypothesis for Redesigning the Academic Spatial Environment

to Encourage Interdisciplinary Collaborations

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**“We shape our buildings;
thereafter they shape us.”**

(Churchill, 1943)

Abstract

Higher education plays a crucial role in addressing the demands of the modern knowledge economy and tackling complex societal challenges. These challenges, often called "wicked problems," require insights and expertise from multiple disciplines. Not only for addressing these challenges but also for enriching the processes of knowledge creation and innovation, fostering interdisciplinary collaboration within the institutions is essential. Architectural design can significantly contribute to facilitating the exchange of ideas and knowledge among people working on diverse disciplines within higher education campuses.

This thesis will investigate how interdisciplinary collaboration can be encouraged in technical universities through spatial design. The objective is to design a project for a portion of the main engineering campus of Politecnico di Torino that proposes a hypothesis for redesigning the academic spatial environment to encourage interdisciplinary collaboration.

The first part of the thesis delves into the birth of technical universities and the impact of the Industrial Revolution on shaping technical education. It also explains the rationale behind the mono-disciplinary design of technical universities' spaces. The campuses of Politecnico di Torino were originally conceived as educational spaces dedicated to single-discipline instruction, which is a model that other technical higher education institutions also adopted.

In the second part of the thesis, quantitative (size, users, uses, distribution, etc.) and qualitative (strengths, criticalities and weaknesses, future directions, etc.) evaluations about the campuses' internal spaces and their organization are done. This study assesses the aspects of Politecnico di Torino campus design that present obstacles to interdisciplinary collaboration. The conclusions from this part are highly relevant for the architectural design proposal at the Politecnico di Torino campus, which will be unfolded in the last part of the thesis.

The third part of the thesis proceeds by reviewing case studies such as the James H. Clark Center, Zollverein School of Management and Design, and the MIT Media Lab to demonstrate how architectural design may foster a culture of interdisciplinary learning and research. This research aims to identify and illustrate effective design strategies that are implemented in these buildings to encourage interdisciplinary collaboration, which other academic institutions can adopt.

The fourth and final part of the thesis draws upon the findings from the case studies, integrating the concepts articulated therein into the project and seeking to address the design obstacles to interdisciplinarity observed in the existing university spaces mentioned in the second part of the thesis.

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Introduction

Interdisciplinarity in Higher Education: Addressing Complex Challenges

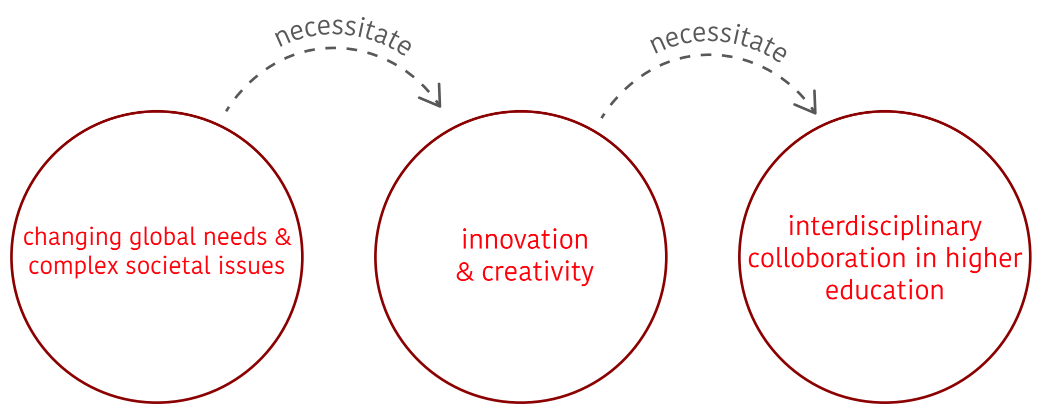
Higher education is changing to meet the new opportunities and challenges posed by the fast changing requirements of the world in the twenty-first century. In today's competitive landscape, "innovation" has become a key driver of success, pushing nations and organizations to foster environments that encourage invention and creativity (Florida, 2012). Higher education holds an important role in this process since it sits the intersection of knowledge generation and societal impact.

A renewed focus on the collaboration among the disciplines emerged as we further progress in the 21st century because of the complexity of today's global concerns that higher education seeks to address. The modern, interconnected, and fast-paced world need creative and innovative solutions, which frequently arise at the intersection of several disciplines. Mansilla and Duraising (2007) contend that combining concepts across disciplines fosters creativity and leads to new outcomes.Through interaction with various viewpoints, interdisciplinary education develops students' diverse skill set and innovative problem-solving abilities, empowering them to tackle real-world issues (Holley, 2017). According to Newell (2001), interdisciplinary education gives pupils a wide range of skills and promotes productive teamwork for a variety of occupations.

In order to address today's "wicked problems" which are poorly defined, complex, and resistent to straightforward solutions, the imputs from range of domains are highly essential. These problems often encompass various fields and cannot be addressed within the confines of a single discipline. Klein (1990) emphasizes that interdisciplinary methods are critical for tackling complex societal issues by integrating diverse perspectives and methodologies.

The disciplinary tradition, often condemned for its restrictiveness and failure to address real-world issues (Tress et al., 2005; Chettiparamb, 2007), is undergoing a change. Universities are increasingly prioritizing the integration of different disciplines and also involving external stakeholders in problem-solving efforts (Hoffman et al., 2016; Vellamo et al., 2019).

Ramaley (2014) posits that universities confronting complex global challenges will prosper in this environment. This necessitates a departure from conventional methodologies. For the reasons described, "interdisciplinary collaboration" has become a vital component of modern academic practice, allowing information from other disciplines to be integrated to promote creativity and innovation.



Defining Interdisciplinarity

Interdisciplinarity in higher education is the integration of knowledge, methodologies, and viewpoints from different academic disciplines to address complex problems, enrich educational experiences, and foster creativity. Interdisciplinary collaboration can help students and researchers get access to a wide range of tools and frameworks. This is because it encourages people from different fields and methods to work together. This strategy is different from traditional, one-discipline methods that might not be able to be powerful in addressing the multifaceted problems of contemporary society (Head & Alford, 2015).

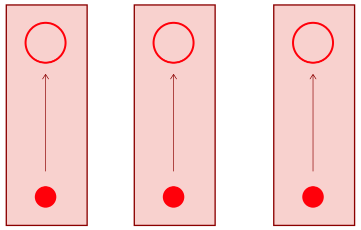
Inter-, multi-, or transdisciplinary research and teaching are not limited to a particular discipline. These terms have different meanings, even though they are often used interchangeably or in similar contexts. Different levels of discipline integration are demonstrated by the differences between multi-, inter-, and transdisciplinary approaches:

- Multidisciplinarity is the cooperation of different academic disciplines investigating the same theme or problem, each with its own disciplinary goals, without crossing subject borders to create new knowledge and theory (Tress et al. 2005).

- Interdisciplinarity advances the multidisciplinary approach by transcending disciplinary barriers and integrating them through shared objectives. Interdisciplinarity involves the creation of cohesive theories and epistemologies. (Vellamo et al., 2019)

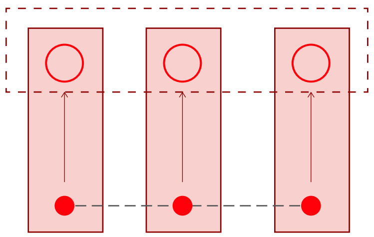
- Transdisciplinary resembles interdisciplinarity; however, it transcends disciplinary, scientific, and academic confines by incorporating academic domains with non-academic contributors. Knowledge and theories are developed through collaboration between academia and society, involving collective goal-setting by participants from various disciplinary and organizational backgrounds, both academic and non-academic (Tress et al. 2005).

- This thesis suggests an interdisciplinary approach to the integration of disciplines because it facilitates effective collaboration without necessitating the complete dissolution of boundaries. Within the boundaries of a traditional university system, which is structured by departments or faculties, it is more tangible and attainable in terms of spatial design.



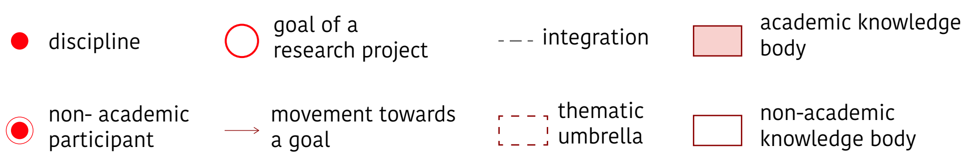
Disciplinary Area

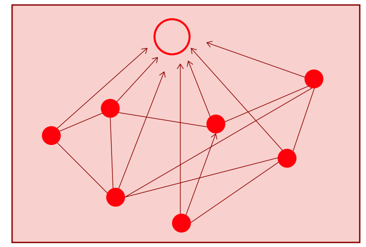
- Within one academic discipline
- Disciplinary goal setting
- No cooperation with other disciplines
- Development of new disciplinary knowledge and theory



Multidisciplinarity

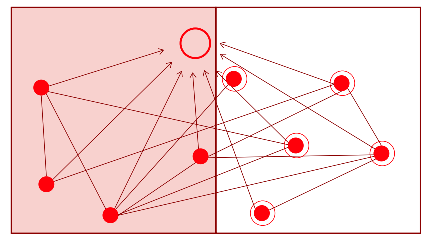
- Multiple disciplines
- Multiple disciplinary goal setting under one thematic umbrella
- Loose cooperation of disciplines for exchange of knowledge
- Disciplinary theory development





Interdisciplinarity

- Crosses disciplinary boundaries
- Common goal setting
- Integration of disciplines
- Development of integrated knowledge and theory



Transdisciplinarity

- Crosses disciplinary & scientific/academic boundaries
- Common goal setting
- Integration of disciplines and non-academic participants
- Development of integrated knowledge and theory among science and society

Figure 1. Overview of research concepts: disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity.

Source: Tress, G., Tress, B., & Fry, G. (2005). Clarifying integrative research concepts in landscape ecology. Landscape Ecology, 20, 479493. https://doi.org/10.1007/s10980-004-3290-4

From the 20th Century to the 21st Century: The Evolution of Interdisciplinarity in Education & Research

There are varying viewpoints regarding interdisciplinarity's origins. Some believe that the notion originated with ancient philosophers including Plato, Aristotle, Rabelais, Kant, and Hegel—all of whom are frequently referred to as "interdisciplinary thinkers" (Klein, 1990). Conversely, some perceive it as a contemporary phenomenon, chiefly resulting from twentieth-century educational reforms, applied research, and the dissolution of disciplinary confines (Klein, 1990). Since the actual term 'interdisciplinarity' did not emerge until the twentieth century, the historical development of interdisciplinarity is most effectively can be traced from the twentieth century onward.

The phrase "interdisciplinarity" was initially used in the context of the Social Science Research Council (SSRC), according to Roberta Frank (1988). In this context, it was used as a simple bureaucratic phrase for describing research initiatives involving collaboration among multiple professional societies—essentially, projects that transcended conventional academic disciplines or organizations. Therefore, "interdisciplinarity" was initially used as a practical term to classify particular kinds of research collaborations rather than as a profound theoretical concept.

Webster's Ninth New Collegiate Dictionary and A Supplement to the Oxford English Dictionary both mention "interdisciplinarity" as having been used for the first time in a December 1937 issue of the Journal of Educational Sociology. The term was utilized in the context of an announcement regarding postdoctoral fellowships provided by the Social Science Research Council (SSRC). This indicates that "interdisciplinarity" was employed in an administrative or academic context concerning research prospects, rather than within an academic article or theoretical discussion (Frank, 1988).

While disciplinary boundaries within academia allowed for efficiency and focus, they also isolated fields of study and constrained intellectual freedom. Interdisciplinarity arose as a response to the constraints, challenging the rigidity of disciplinary boundaries (Hearn, 2003).

Interdisciplinarity in academia has been promoted by a number of movements (Chettiparambs, 2007). Starting in the 1920s, social science research and the 'universal education movement' integrated multidisciplinary methodologies into academia (Klein, 1990). The integration of information from the natural sciences, social sciences, and humanities was encouraged by the Unity of Science movement in the 1930s and 1940s. This post-World War I movement sought to promote a comprehensive view of the world in order to address the fragmentation of knowledge (Hearn, 2003).

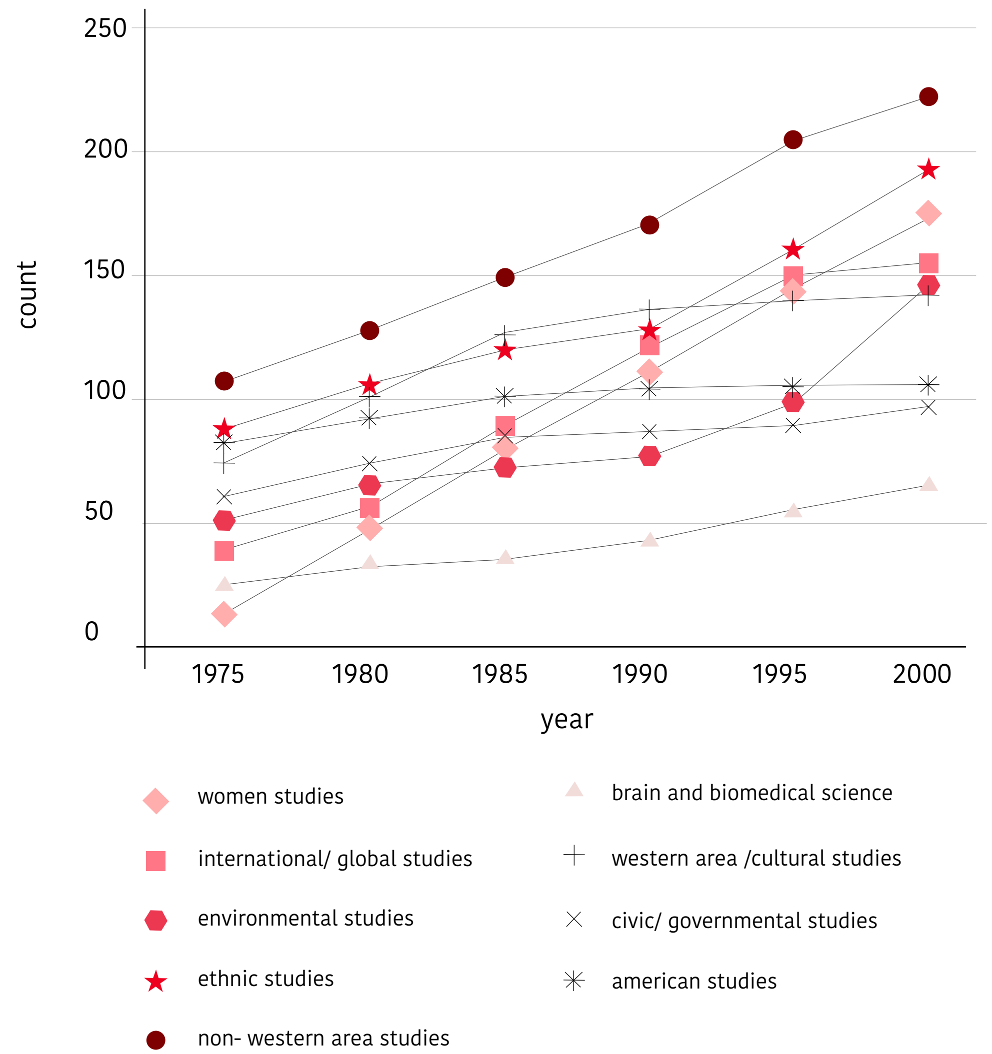
The institutionalization of interdisciplinarity was accelerated by World War II. In order to tackle major issues like creating new technologies and resolving social and economic concerns like post-war reconstruction, both governments and industries looked to universities. The social sciences brought together fields such as political science, economics, and sociology to examine and solve societal issues. In the meantime, physics, engineering, and mathematics worked together on industrial and military research projects. These multidisciplinary endeavors demonstrated how several fields could collaborate to meet the complex demands of the time (Hearn, 2003).

During the 1960s and 1970s, there was a notable increase in interdisciplinary innovation as mission-oriented research shifted to tackle societal issues such as environmental quality and public health. Institutions such as the National Science Foundation (NSF) have been helpful in financing problem-focused interdisciplinary research (Klein, 1990).

By the late 20th century, academia saw a transition from specialization, with interdisciplinary collaboration becoming a hallmark of academic evolution (Heilbron, 2004; Brint et al., 2009). Interdisciplinarity has gained widespread acceptance and formalization in academic institutions in this period. To address intricate, multidimensional issues, universities created specialized interdisciplinary departments and programs, such as gender studies and environmental science. Additionally, through targeted funding, governments and private organizations started giving interdisciplinary studies priority, supporting initiatives that addressed pressing issues like public health and climate change (Brint et al., 2009). Brint et al. (2009) highlighted the growth of interdisciplinary fields, showing that the number of programs organized as interdisciplinary units, rather than traditional departments, increased significantly between 1975 and 2000. They demonstrated this growth through an analysis of nine major interdisciplinary fields. (see Graphic 1)

In the 21st century, colleges have built interdisciplinary institutions to acknowledge the advantages of integrating disparate knowledge. At ZKM Karlsruhe, for instance, the collaboration of art and technology fosters new ways of perceiving and engaging with artistic works. Similarly, the efforts of experts at MIT's Media Lab also show how interdisciplinary research can result in innovative products that improve people's quality of life. (Baletic et al., 2017)

This historical trajectory highlights the lasting significance and transformative capacity of interdisciplinarity. Currently, esteemed institutions such as MIT Media Lab, Stanford Bio-X, and ETH Zurich are investing in cutting-edge facilities designed to promote interdisciplinary education and research, reflecting a global trend towards an integration of disciplines in academia and infrastructure.



Graphic 1. Growth rates of nine large interdisciplinary fields 1975- 2000

Source: Brint, Steven & Turk-Bicakci, Lori & Proctor, K. Ryan & Murphy, Scott. (2009). Expanding the Social Frame of Knowledge: Interdisciplinary, Degree-Granting Fields in American Colleges and Universities, 1975–2000. The Review of Higher Education. 32. 155-183. 10.1353/rhe.0.0042.

Why Interdisciplinary Education is Essential for Technical Universities?

By creating new knowledge and innovations and addressing intricate issues by creating interdisciplinary structures, universities play a crucial role in society (Välimaa et al., 2016). As integral parts of higher education, technical universities must also adapt to these expectations.

Technical disciplines and engineering play a pivotal role in addressing a wide range of complex global challenges. (Vellamo et al., 2019) However, there are some studies that have started to question whether traditional engineering education is socially relevant, especially when it comes to tackling wicked problems. (Edström, 2017; Lönngren, 2017). Engineering education has faced criticism since it focuses only on technical skills and often overlooks broader social, political, and environmental concerns, as well as other real-world issues (Denis and Heap, 2012). In addition to that, with its current rigid and pragmatic structure, it may be challenging for engineering education to confront wicked problems.

In her PhD dissertation, Lönngren (2017) demonstrates that a strong engineering paradigm creates a disciplinary culture that uses standardized methods and has objective data. Other perspectives and worldviews are not valued in this discipline's culture. Since the wicked problems require the integration of various domains of expertise, this feature of engineering education may fall short when dealing with such challenges.

Therefore, the social relevance of technical education would be improved by breaking down academic silos and integrating varied viewpoints from various disciplines. To improve inherent worth and more effectively address the aforementioned wicked problems, technical education might forsake traditional approaches and foster cooperation with outside stakeholders and other disciplines (Head and Alford, 2015).

Moving Forward: Strategies for Promoting Interdisciplinarity in Technical Universities

Higher education institutions are under growing expectation to produce collaborative, interdisciplinary knowledge (National Science Foundation, 2004; Pfirman et al., 2005; Rhoten, 2003). The transition to interdisciplinarity is not merely an academic modification; it signifies a reevaluation of the organization and use of knowledge. In order to foster collaborative problem-solving and the growth of shared expertise across academic disciplines, it calls for a fundamental reevaluation of the roles and duties of faculty, staff, and students (Ramaley, 2016).

According to Morphew and Hartley (2006), the institutional mission cannot simply be defined; rather, it is constructed through organizational, physical, and cultural efforts.Therefore, integrating interdisciplinarity into higher education requires curricular, structural (including the establishment of new administrative offices, recruitment of interdisciplinary faculty, or creation of interdisciplinary facilities), and cultural changes (such as promoting collaborative leadership and revising institutional objectives) within higher education institutions (Harris & Holley, 2008).

Technical universities can foster interdisciplinary collaboration by rethinking their curriculum, providing interdisciplinary courses and programs, promoting interdisciplinary research, redesigning spaces, fostering collaboration between departments, and building a culture that values and rewards interdisciplinary work.

The fragmented, segmented frameworks of curricula can give way to more integrated and cohesive models that encourage the interconnection of ideas across disciplines.
In conjunction with these curricular modifications, the physical spaces of university campuses can be effective in fostering collaboration across disciplines. According to Harris and Holley (2008), the growth of interdisciplinarity as a guiding principle for academic programs (Frost et al., 2004), institutional organization (Sa, 2007), and research (COSEPUP, 2004) requires concurrent changes in institutional space planning and facilities use.

Scholars emphasize the importance of infrastructural changes, stating:

"Due to its diversity of facilities and its complexity, the modern university or college is increasingly becoming a place of social activity and exchange... The traditional Anglo-saxon campus model, where separate buildings underline the independence of faculties... can really no longer function in our world... Nowadays we are concerned with more than the acquisition of specialized professional knowledge, and attention is shifting to the issue of what one discipline may mean in relation to another and, as such, to exchange. Infrastructure must take such matters into account. " (Hertzberger & Ten Kate, 2018)

Therefore, there is a growing call to redesign educational spaces and curriculums to foster interdisciplinary thinking. Some universities around the globe have recognized the necessity of adapting both their curricula and spaces to encourage collaboration across disciplines. As academic discourse moves away from the conventional "siloed" approach and into an increasingly network-oriented, collaborative framework, this architectural change reflects that evolution. Stanford University and MIT are two universities that have acknowledged this change and its importance in educating students for the intricate, interrelated issues of modern society.

Challenges in Encouraging Interdisciplinary Collaboration at Technical Universities

Even though interdisciplinarity has an important role in addressing complex issues, implementing it in higher education poses a number of challenges. These challenges can be classified as structural, budgetary, and cultural challenges that stand in the way of successful interdisciplinary teaching and research. Understanding and addressing these challenges is essential for creating an environment conducive to effective collaboration among diverse disciplines.

A significant obstacle is cultural resistance. Conventional academic cultures have historically prioritized specialization and expertise in individual disciplines, resulting in a sense of territoriality regarding resources and acknowledgment. Consequently, departmental silos have emerged, with departments working independently rather than collectively. This situation caused hesitance among various scholars and administrators regarding the adoption of interdisciplinary education. Implementing a model that encourages collaboration is crucial for overcoming this reluctance and changing the notion of academic value.

Encouraging collaboration between disciplines in higher education poses financial challenges as well as cultural ones. Depending on their organizational structure and position in the institutional hierarchy, interdisciplinary programs may have trouble generating income (Holley, 2009). This is because interdisciplinary efforts are frequently marginalized in favor of specialties with established economic advantages. As a result, resources for interdisciplinary programs get constrained. Kvavik and Roberts (2009) have indicated that the persistent deficiency of funding for multidisciplinary spaces hinders the establishment of environments favorable to collaborative research and learning. Insufficient funding prevents interdisciplinary projects from being acknowledged within organizations. Scholars like Klein & Falk-Krzesinski (2017) and Mansilla et al. (2015) emphasize the need for institutional support and resources to establish a learning atmosphere that supports an education that integrates diverse disciplines. They claim that interdisciplinary projects are unlikely to succeed if the administration does not provide strong support.

Rigid frameworks of many universities, typically organized into distinct departments that reinforce disciplinary boundaries, pose structural challenges in encouraging interdisciplinary collaboration among the students and researchers. These frameworks constrain the potential for interdisciplinary collaboration (Holley, 2017). The physical spaces of these institutes further reflect this organizational division. Each discipline or department is distributed in separate zones, including classrooms, laboratories, and administrative units that are tailored to their own activities. This organization causes the sense of isolation among the students and researchers.

Some buildings are repurposed for new knowledge opportunities, while others are newly constructed to address these structural concerns, reflecting the institution's commitment to interdisciplinary work (Harris & Holley, 2008). The James H. Clark Center is an excellent example of how universities like Stanford University have made investments in cutting-edge interdisciplinary infrastructure. This center seeks to advance research involving multiple disciplines by offering shared spaces that encourage cooperation in order to develop scientific inquiry and innovative solutions to societal problems.

Many technical universities face structural obstacles in promoting interdisciplinary collaboration with their current physical infrastructures, including Politecnico di Torino, one of the oldest technical universities on the European continent. The original design of these campuses had separate, department-specific areas, which restricts students' and researchers' ability to engage in collaborative work. The purpose of this thesis is to explore how, in the academic environment of Politecnico di Torino, architectural design can encourage interdisciplinary collaboration.

In order to achieve this, The thesis starts by determining the rationale behind the university spaces' monodisciplinary structure. It examines into the history of technical universities, the educational ideas that gave shape to their campus designs, and how these ideas have affected the way their spaces are arranged and designed.

The second part of the thesis, the elements within Polito spaces that create barriers to interdisciplinarity, are thoroughly examined and evaluated. The thesis pursues a qualitative approach to explore the spatial and organizational needs and particular problems associated with the design of the Politecnico di Torino campuses in promoting interdisciplinarity.

To understand how interdisciplinary collaboration was achieved through spatial design in different higher education institutes, the research draws on case studies of existing university campuses, such as Stanford University's James Clark Center, Zollverein School of Management and Design, and MIT Media Lab, to examine how design choices influence interdisciplinary interactions. These examples show how certain design concepts that encourage interdisciplinary partnerships are applied in the real world.

Building upon these understandings, a design proposal will be presented for a portion of the Main Engineering Campus of Politecnico di Torino, focusing on creating an environment in which interdisciplinary collaboration is fostered.
An initial prerequisite to designing an educational space that encourages interdisciplinary collaboration is understanding what kinds of teaching and learning activities the space should enable and to clearly define the the scope of interdisciplinarity before moving forward.

The campus development could go in two main directions:

- Focusing on fostering interdisciplinary interactions within each campus's current user base (departments)
- Expanding interdisciplinarity to include connections across all departments and campuses

Each of these approaches requires a different design strategy and affects the arrangement of educational spaces for the specific needs of curriculum, learning, laboratory and workshop activities. The decision can additionally depend on the planned kinds of interdisciplinary projects and research in the future. The proposal that the thesis presents was shaped according to the second approach to interdisciplinary possibilities, focusing on an integrated, university-wide environment across all departments.

The goal of this thesis is to present a conceptual framework rather than a specific solution. It proposes an approach on how to encourage interdisciplinarity by spatial design, rather than providing a design based on a specific requirement. Instead of proposing a concrete or practical solution, the thesis aims to offer a foundation of concepts, relationships, and perspectives that can guide the interpretation or resolution of the issue at hand, serving as a framework for thinking about the question without prescribing a single definitive answer.

The ultimate goal of this thesis is to contribute to the ongoing discourse on enhancing educational practices in higher education institutions, especially technical universities. Even if there is no specific need at the moment, it might be helpful while discussing the future of this building.

I. Remnants of the Industrial Age

The Industrial Age & the Birth of Technical Universities

“When we deal with buildings, we deal with decisions taken long ago for remote reasons.”

(Brand,1994)

This quote is from the book “How Buildings Learn: What Happens After They’re Built.” It highlights the importance of historical context in understanding architecture. The movements and needs of their time had a significant impact on their state and structure. Similar to this, technical university campuses’ design embodies the historical, cultural, and technological settings of their respective eras and are physical representations of the goals and requirements of the times in which they were designed.

During the nineteenth century, the industrialization of Europe created a pressing need for highly qualified workers. Because of the swift advancement of technology and its use in industrial production, there was a greater need for qualified engineers and civil servants, especially in the technical fields of construction and the military. (Bott, 2018). In response to this requirement, technical universities were established to provide professional training to satisfy these demands. During this period, the growing need for professional education and technical knowledge was closely related to the establishment of these institutions (Guagnini, 2004).

A number of notable developments laid the groundwork for the foundation of technical universities. For the training of engineers and other professionals for public service, state ministries of public works, commerce, or military established advanced technical schools at the beginning of the nineteenth century. Initially, they were specialized academies with a focus on particular fields of study, such as military or civil engineering. Over time, these institutions expanded their curriculums with more technical and scientific courses. (Guagnini, 2004).

The quantity and quality of higher technical education institutions increased as a result of the growing demand for formal, structured education in technical and applied sciences as industrialization spread throughout Europe (Guagnini, 2004).

In revolutionary France, the specialized civil colleges were founded. Over time, these specialized colleges evolved into Grandes écoles. One of the most influential Grandes Écoles, the École Polytechnique in Paris, emerged as a pioneering institution that became a model for successive technical universities in Europe (Bott, 2018). This school established an educational model that features a strong theoretical foundation in physics and mathematics and integrates practical applications. This school educational model for technical education throughout Europe (Guagnini, 2004).

During times of industrial and scientific progress, the increasing need for specialized technical education led to the development of polytechnic schools. These institutions frequently sprang from pre-existing institutions or intellectual movements. Karlsruhe Polytechnic School (now referred to as the Karlsruhe Institute of Technology or KIT) established in 1825 by Johann Gottfried Tulla, a pioneering engineer, and Friedrich Weinbrenner, a prominent architect. This institution is acknowledged as Germany’s first institution to embody the contemporary notion of a technical university. École Polytechnique likely had an influence over Tulla’s vision for the Polytechnische Schule Karlsruhe (Bott, 2018).

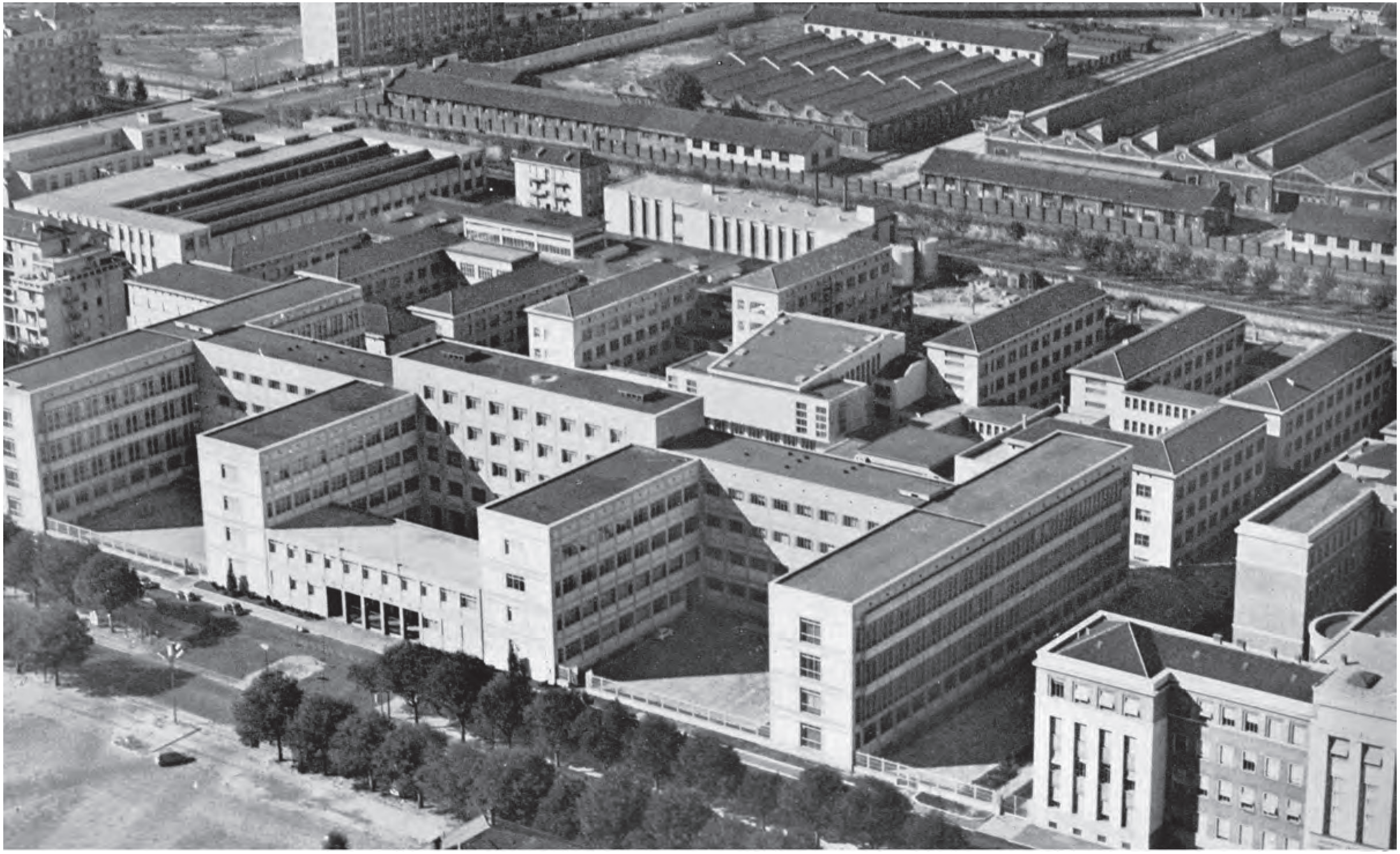


Image 1. Aerial view of the campus on Corso Duca Abruzzi when it was recenty built

Source: Ministero dei Lavori Pubblici. (1958). 'Nuova sede del Politecnico di Torino: Planimetria generale'. Provveditorato alle Opere Pubbliche per il Piemonte.

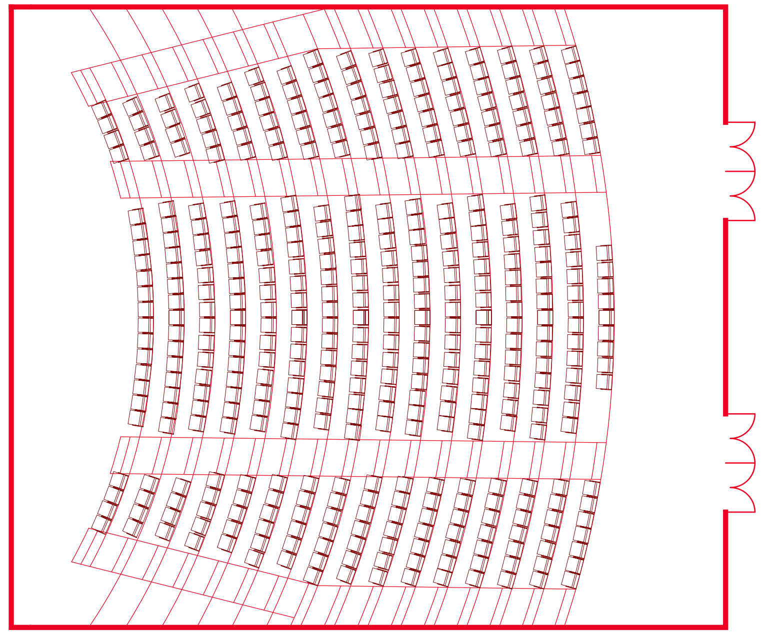
The Interplay of Pedagogy & Space: Form Follows Function & Vice Versa

The relationship between buildings and their function is frequently demonstrated by two statements. The first dates back to the late nineteenth century and is the well-known statement by Louis Sullivan that “Form ever follows function” (Sullivan, 1896). The second, from Winston Churchill, offers a different view: “We shape our buildings, and afterwards our buildings shape us.” (Brand, 1994).

As in the case of educational environments, the relationship between pedagogy and space is intricately linked, resonating with Churchill’s viewpoint, as both reciprocally shape and affect each other in a dynamic interaction.

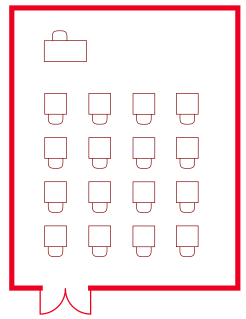
Torin Monahan uses the term “built pedagogy,” which he defines as the “architectural embodiment of educational philosophies” (Monahan, 2002). The design of educational environments—classrooms, libraries, and laboratories—directly influences the teaching and learning activities occurring within those spaces. A room’s spatial arrangement affects the instructional methods used as well as how engaged students are with the content.

For instance, while traditional, lecture-centric models are better suited for fixed, linear seating arrangements, collaborative learning solutions usually require flexible, open spaces that encourage group interaction.



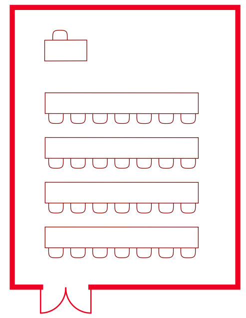
type 1. Lecture Hall

suitable for frontal teaching for a big number of students



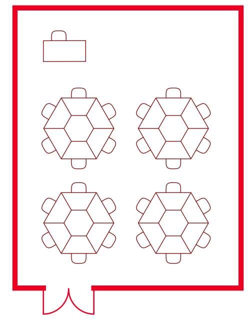
type 2. Classroom for frontal teaching

interactions between the students are not considered



type 3. Classroom for frontal teaching

interactions between the students are limited



type 4. Collaborative classroom

conducive for collaborations between the students

Strange and Banning (2001) emphasize this point by stating that while the physical environment offers countless opportunities, the way space is arranged and structured makes some behaviors much more likely than others. This emphasizes that architecture is not merely a passive setting but an active participant in the educational process. The architecture of a space naturally facilitates specific pedagogical approaches while constraining others.

As it is explained in the previous part, technical universities emerged as a response to the spreading industrialization throughout Europe. The pedagogical model of the Industrial Age emulated assembly line efficiency, characterized by a top-down transmission of information from instructor to student, commonly referred to as the “sage on the stage” method (Webber, 2009). This universal model effectively disseminated knowledge to a large number of students but offered almost no opportunities for interaction or collaboration. The architectural arrangement of educational institutions in the Industrial Age highlights the persistent prevalence of conventional didactic models that emphasize knowledge transmission rather than interactive or experiential learning.

These organizations’ spatial layouts reflected their objectives: classrooms were frequently spacious, rectangular spaces intended for efficiency rather than social contact. The main corridors connected the smaller classrooms and laboratories where specialized courses were held in a straight line resembling an assembly line.

Built in the middle of the 20th century, Politecnico di Torino’s Main Engineering campus embodies the pedagogical models and educational goals of the era.

The outcome is a complex characterized by a ‘scholastically functionalist’ approach. The design efficiently facilitates teaching, learning, or academic work with a strong emphasis on practicality and efficient organization. With no ornamentation or extraneous components, the spaces are simple and utilitarian.

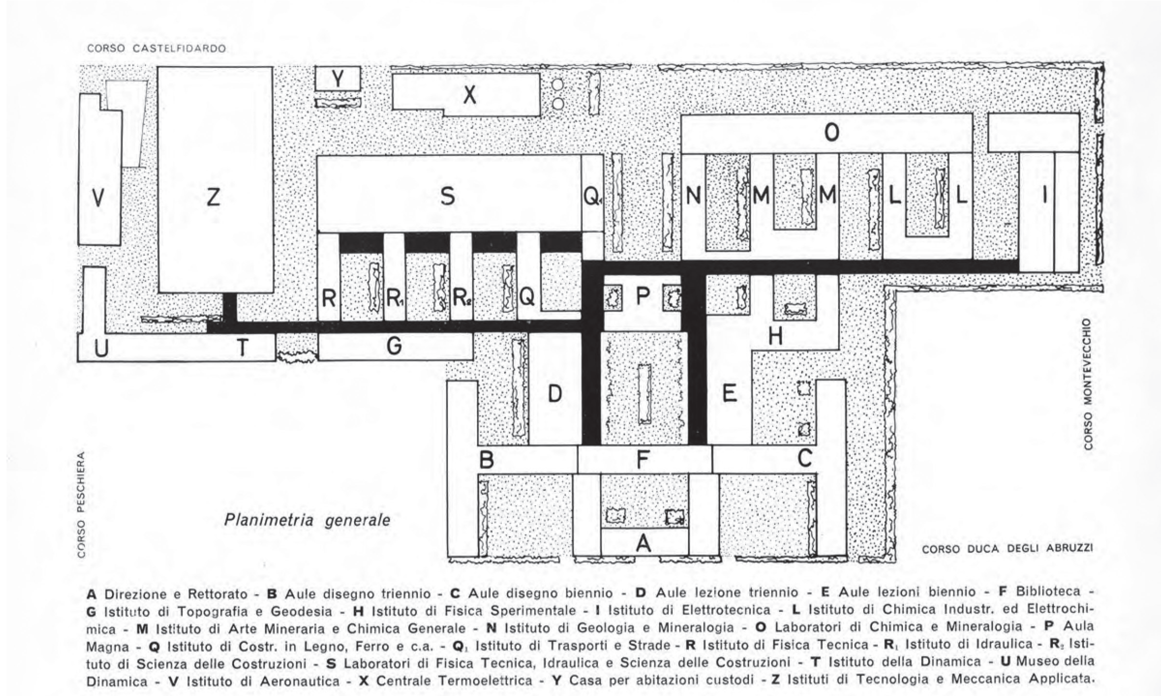


Image 2. Schematic drawing of the campus on Corso Duca Abruzzi

Source: Ministero dei Lavori Pubblici. (1958). ‘Nuova sede del Politecnico di Torino: Planimetria generale’. Provveditorato alle Opere Pubbliche per il Piemonte.

The campus has an axial organization. The spaces are arranged along a central axis, which acts as the structural backbone. This axis links key areas and maintains the major flow of movement within the building. The separate spaces for disciplines are also aligned along this central line.

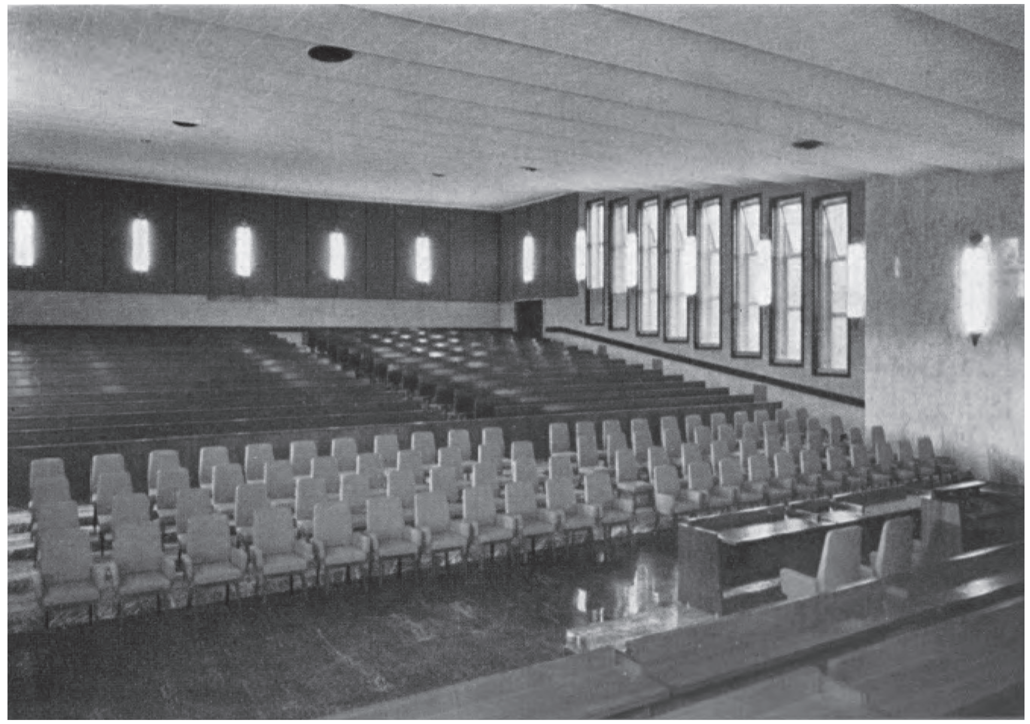
The circulation, both internal and exterior, is characterized by geometric, linear patterns that emphasize efficiency and order. This circulation method facilitates efficient navigation throughout the building, yet it diminishes opportunities for informal interactions.

Spaces like the Rectorate, Aula Magna, and main administrative offices occupy prime positions in the organization. Their significance in the academic framework is embodied in their accessibility, large scale, and central positions. Users can immediately comprehend the importance of each area based on its placement and scale as a result of the clear spatial order.

The teaching activities are mainly taking place in large auditoriums, which is convenient for frontal teaching for a high number of students. The teaching classrooms occupy the two wings facing the main courtyard, with a total overall capacity of about 2,500 students.

The design of the campus spaces has given little emphasis on fostering engagement among occupants. The common spaces within the building are basically serving the main functions such as teaching and research activities, and the large courtyards recall the grandeur of the institution. They are not effectively designed to encourage further interaction outside the classrooms.

In overall design, there is minimal focus on flexibility or informal interaction. The space is functional, purposeful, and easy to navigate, serving the specific needs of the academic community.



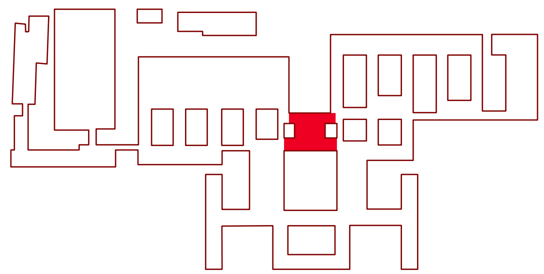
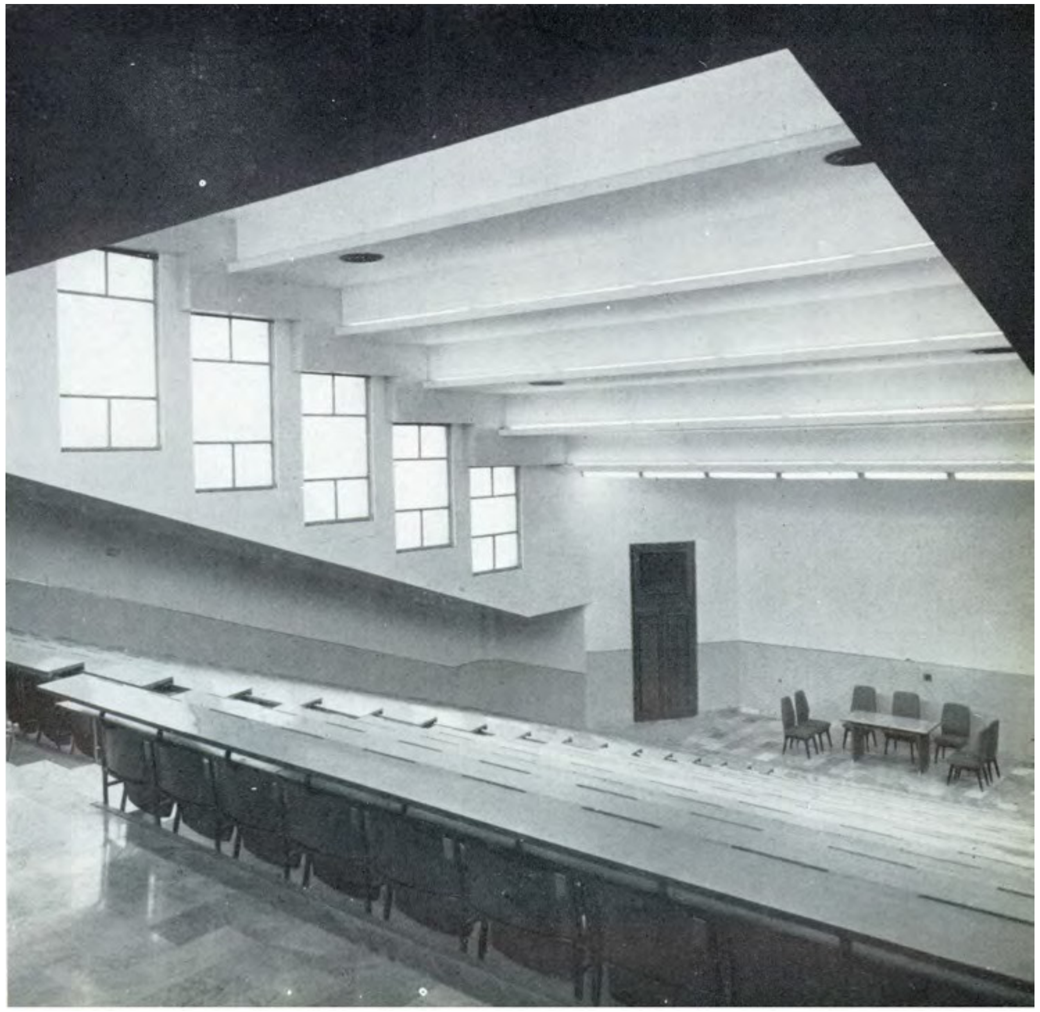


Image 3. Aula per disegno at the campus on Corso Duca Abruzzi

Source: Ministero dei Lavori Pubblici. (1958). 'Nuova sede del Politecnico di Torino: Planimetria generale'. Provveditorato alle Opere Pubbliche per il Piemonte.



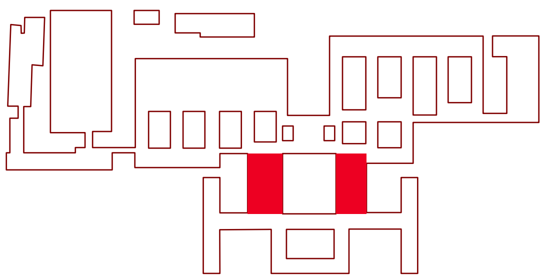
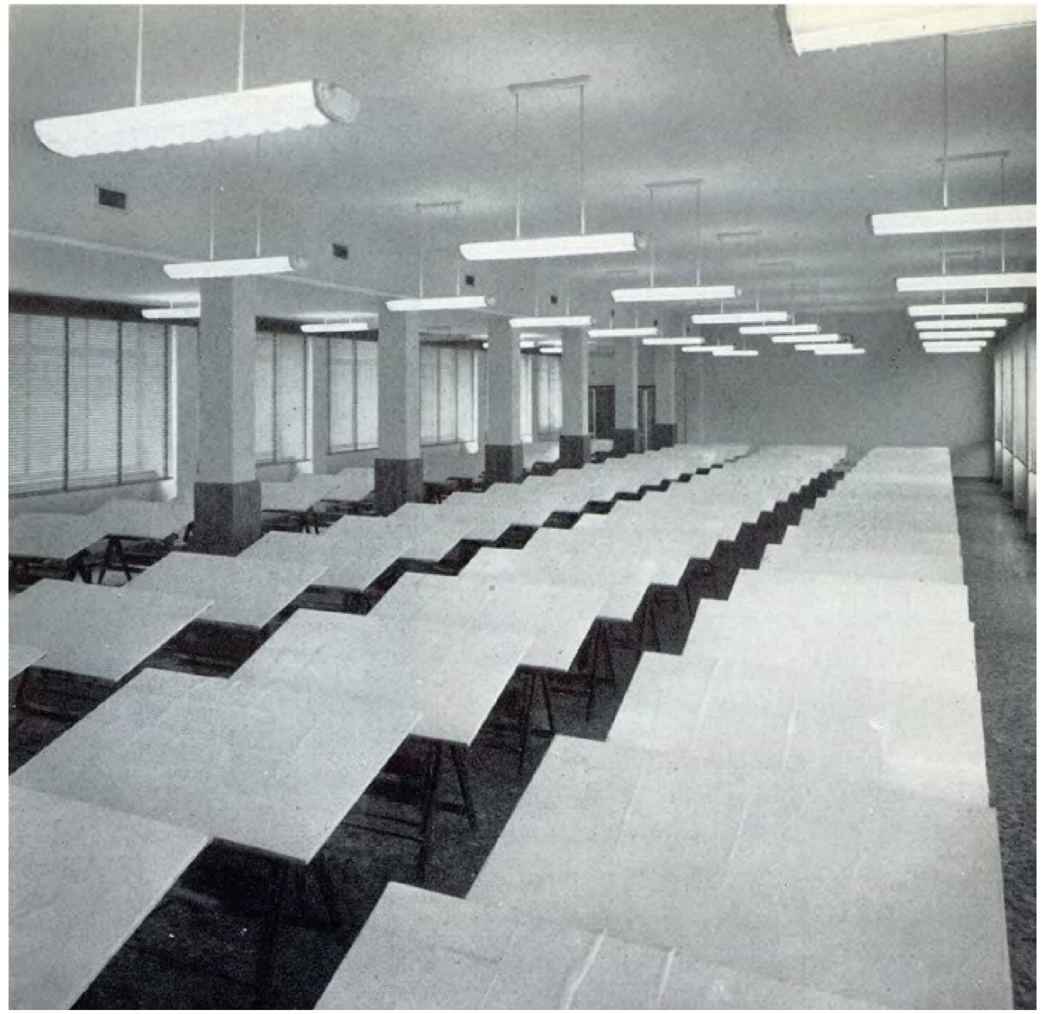


Image 4. Aula per insegnamento the campus on Corso Duca Abruzzi

Source: Ministero dei Lavori Pubblici. (1958). 'Nuova sede del Politecnico di Torino: Planimetria generale'. Provveditorato alle Opere Pubbliche per il Piemonte.



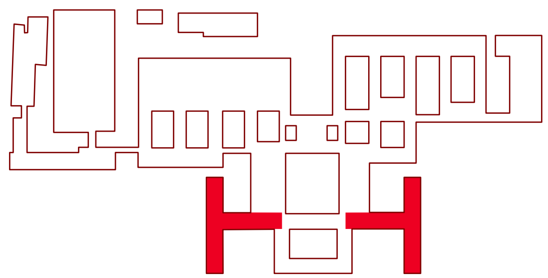
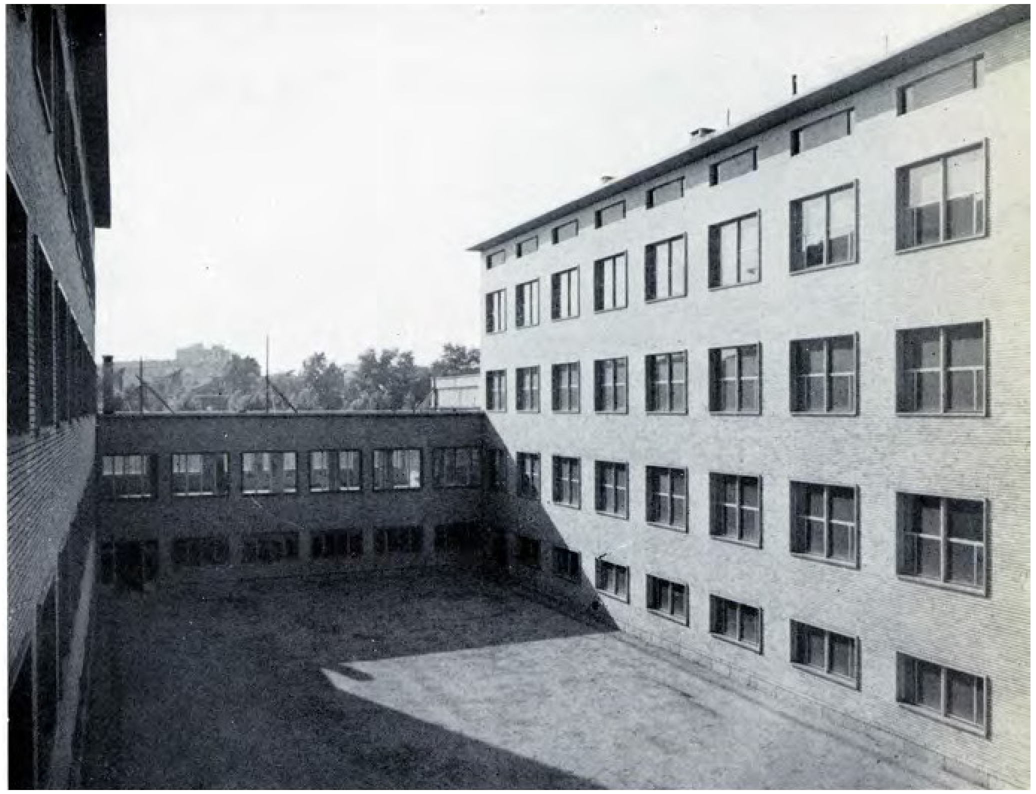


Image 5. Aula per disegno at the campus on Corso Duca Abruzzi

Source: Ministero dei Lavori Pubblici. (1958). 'Nuova sede del Politecnico di Torino: Planimetria generale'. Provveditorato alle Opere Pubbliche per il Piemonte.



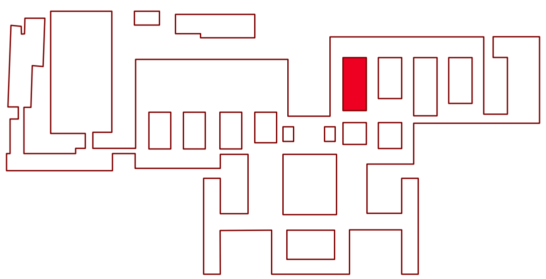


Image 6. One of the courtyards between the departmental spaces at the campus on Corso Duca Abruzzi

Source: Ministero dei Lavori Pubblici. (1958). 'Nuova sede del Politecnico di Torino: Planimetria generale'. Provveditorato alle Opere Pubbliche per il Piemonte.

Mono-disciplinarity in Technical Universities

The disciplinary organization in higher education institutes emerged long before technical universities did. The origins of disciplinarity can be found in the medieval universities of Paris (1150) and Bologna (1088), where knowledge was organized according to specialized professions like theology, medicine, and law. These fields were strongly linked to societal requirements and external authorities such as church and state. Although the earliest roots of disciplinarity in higher education had been laid prior to the industrial revolution, the forces of industrialization considerably strengthened and institutionalized it. The Industrial Revolution consolidated disciplinary structures and raised the need for professional knowledge in disciplines. (Hearn, 2003)

Consequently, higher education institutes started the reorganization of their curricula and departments to align with this change in societal demands. The division of labor, which is a fundamental principle in industrial production, impacted educational institutions. They started adopting a similar approach by organizing knowledge into distinct academic disciplines and specialties (Rothblatt, 1997).

This inclination towards specialization was also influenced by the imperatives of effciency. Mono-disciplinary departments enabled students to acquire profound knowledge in a singular domain, such as engineering, medicine, or economics, which were regarded assessential to national industrial objectives. The emphasis on specialized knowledge aimed to equip graduates for direct contributions to the industrial economy, reflecting the specialization observed in the job market (Weingart, 2010).

The exigencies of industrialization compelled educational institutions to adopt specialization, resulting in dierent disciplines that have emerged as the organizational structure for the knowledge (Clark, 1983). This notion is also reflected in the physical spaces of university campuses, which have been segmented into distinct spaces or structures allocated to specialized disciplines. Their spatial relationship mirrors their organizational relationship, which leads to isolated spaces for people focusing on dierent disciplines.

Similar to many other examples across Europe, the design of the Politecnico di Torino campuses reflects a monodisciplinary focus. Currently, the university has several sites, including the Main Engineering Campus, Valentino Campus, Lingotto Campus, and Mirafiori Campus in Turin. The Main Engineering Campus at Corso Duca Abruzzi and Valentino campuses host the departments, and the other two campuses are mainly used for teaching activities for various departments.

Although the university environment has changed, its layout still reflects the industrial roots of technical education, having areas designated for certain fields and infrequently encouraging interdisciplinary cooperation among these disparate fields. Individuals within disciplinary community are dedicated to deepening expertise within their area of study. Each structure is composed of research laboratories, classrooms, ateliers, and other spaces that have the specific characteristics —the shape, dimension, organization—to accomodate various activities.

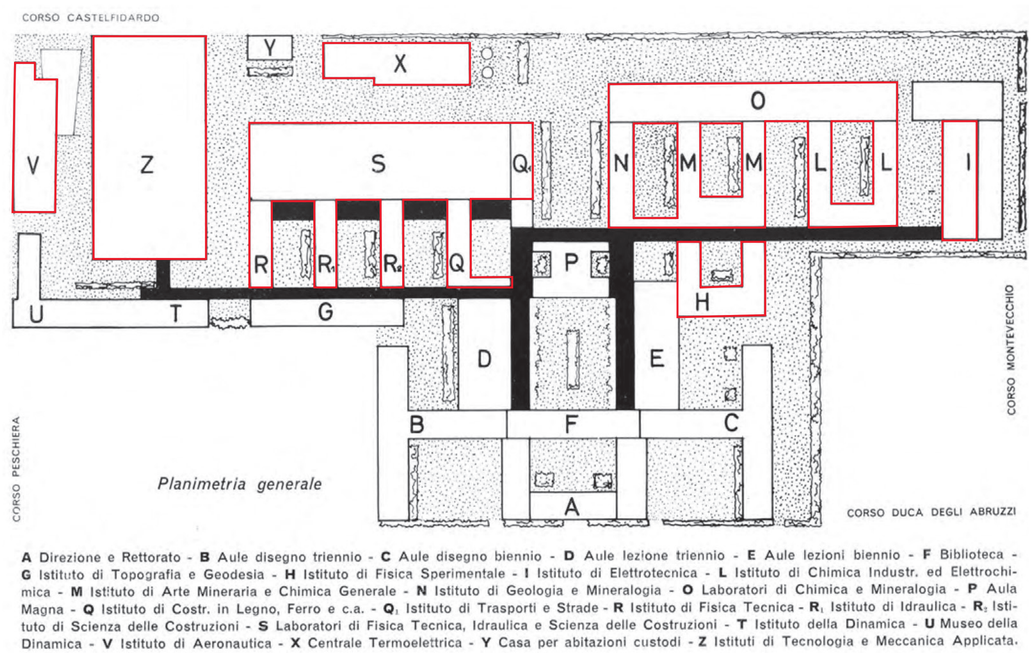


Image 7. Schematic drawing of the campus on Corso Duca Abruzzi when it is recently built

Source: Ministero dei Lavori Pubblici. (1958). 'Nuova sede del Politecnico di Torino: Planimetria generale'. Provveditorato alle Opere Pubbliche per il Piemonte.

II. Tracing the Barriers against Interdisciplinary Collaborations

In addition to other factors that help achieve this objective, spatial design is a very powerful instrument to encourage interdisciplinary collaboration, as pointed out in the introduction.

Karri Halley and Michael Harris (2008) analyzed how higher education institutes cultivate an interdisciplinary culture by utilizing campus' physical spaces. In the article, the findings of an extensive assessment of campus master plans and strategic plans from 21 universities classified as very high research institutions are discussed. They discovered that rather than limiting knowledge generation to specific, well-defined areas, interdisciplinary work requires collaboration among people with diverse areas of expertise across the entire university. Kvavik and Roberts (2009) also discovered that university environments promoting interdisciplinary collaboration prioritize the creation of public spaces and meeting areas **to facilitate interactions** among researchers, students, and even the public.

An interdisciplinary community is fostered through the shared characteristics of faculty and students, as well as a shared physical and social space. However, since traditional physical and social spaces of the universities, which are frequently identified by departments, do not allow for the engagement of individuals from multiple disciplines, it is challenging for universities to achieve the successful implementation of interdisciplinary education. (Harris & Holley, 2008)

In addition to encouraging interactions, through an empirical analysis of institutional documents, Harris and Holley (2008) highlighted the importance of **flexibility in spaces** in order to effectively foster interdisciplinary collaboration. Because of the **changing nature of interdisciplinary teaching and research**, it is very important to have facilities that are flexible and modular in their design and construction (Kvavik & Roberts, 2009). In order to accommodate diverse interdisciplinary curricula, programs, research, etc., the spaces should be adaptable. This flexibility enables easy reconfiguration or modification of the spaces and helps them to evolve alongside the changing needs. For example, Building 20 at MIT brought an unexpected benefit to interdisciplinary research. It was a temporary, timber structure that was built after World War II and has served the institution for half a century. Thanks to its plywood construction, the occupants could modify their environment at will depending on different activity requirements.

Therefore, the emergence of interdisciplinary activity affects not only the departmental organizational structure but also the **institution's physical settings** and **social relations within them**.

Image 8. Building 20

Source: MIT Museum. (n.d.). Building 20 [Photograph]. MIT Museum Collections. Retrieved February 3, 2025, from https://mitmuseum.it.edu/collections/subject/building-20-37

Spatial Separation of Disciplines

Several higher education institutes in Europe still have architectural designs that are reminiscent of industrial-age education, with compartmentalized academic areas under the control of departments that are each specialized in a particular field of study.

The traditional Anglo-American campus model, which is characterized by separate buildings for different specializations, is no longer suitable for the demands of contemporary society, according to some authors, such as Herman Hertzberger and Laurens Jan ten Kate (2018). The construction of interdisciplinary facilities also acknowledges that the discrete spaces of the university are restricted in their ability to foster interdisciplinary collaboration (Harris & Holley, 2008).

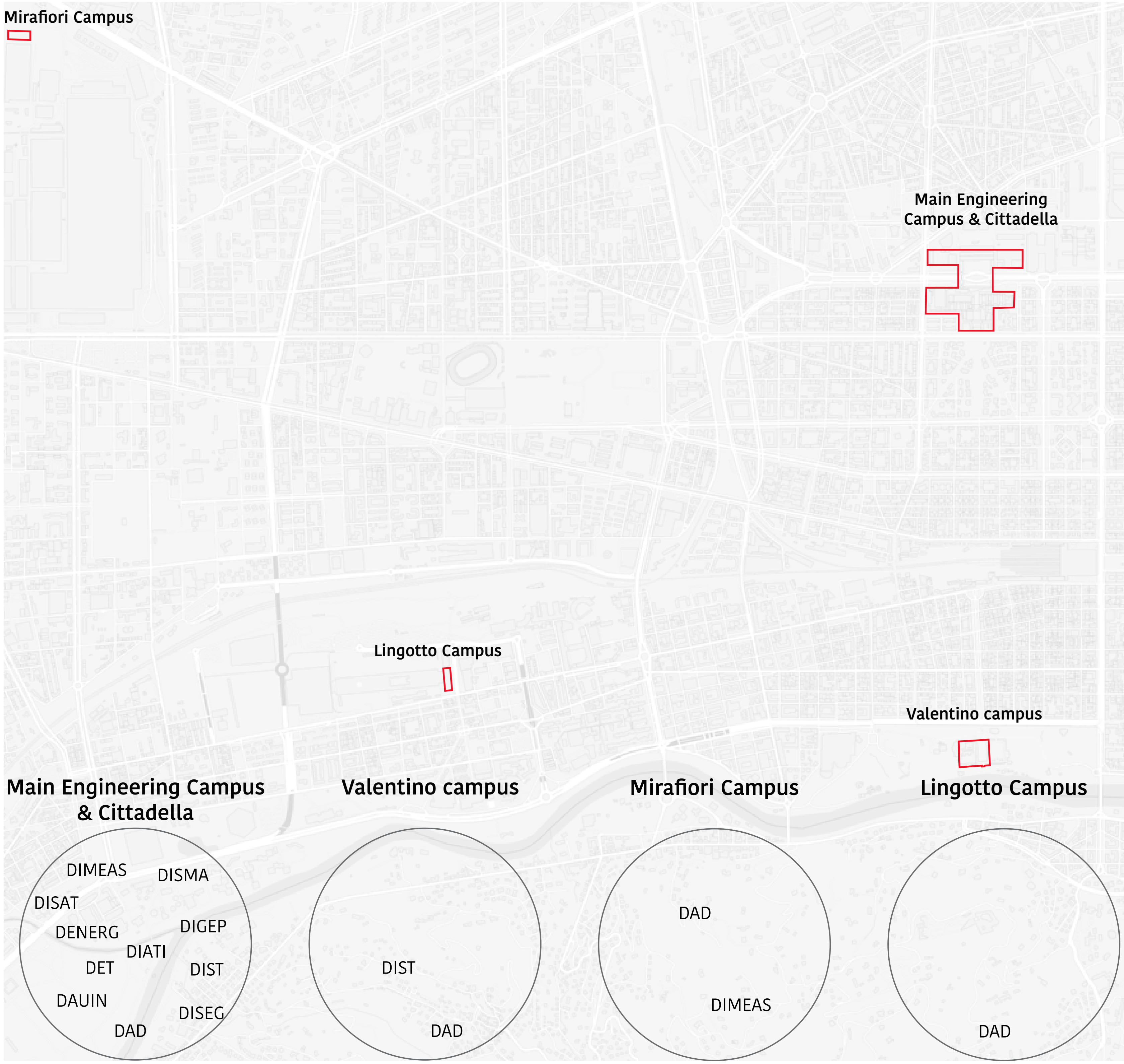
Physically separating departments over numerous buildings or campus spaces may make it difficult for people to move freely and engage with one another, which leads to the formation of intellectual silos. This design element lessens the likelihood of collaborative work among disciplines and incidental meetings.

In a well-structured campus, walkability and closeness are essential for promoting interdisciplinary collaboration. City campuses, like Politecnico di Torino, encounter this issue due to the considerable distance between their numerous locations, which exacerbates the isolation of disparate academic communities.

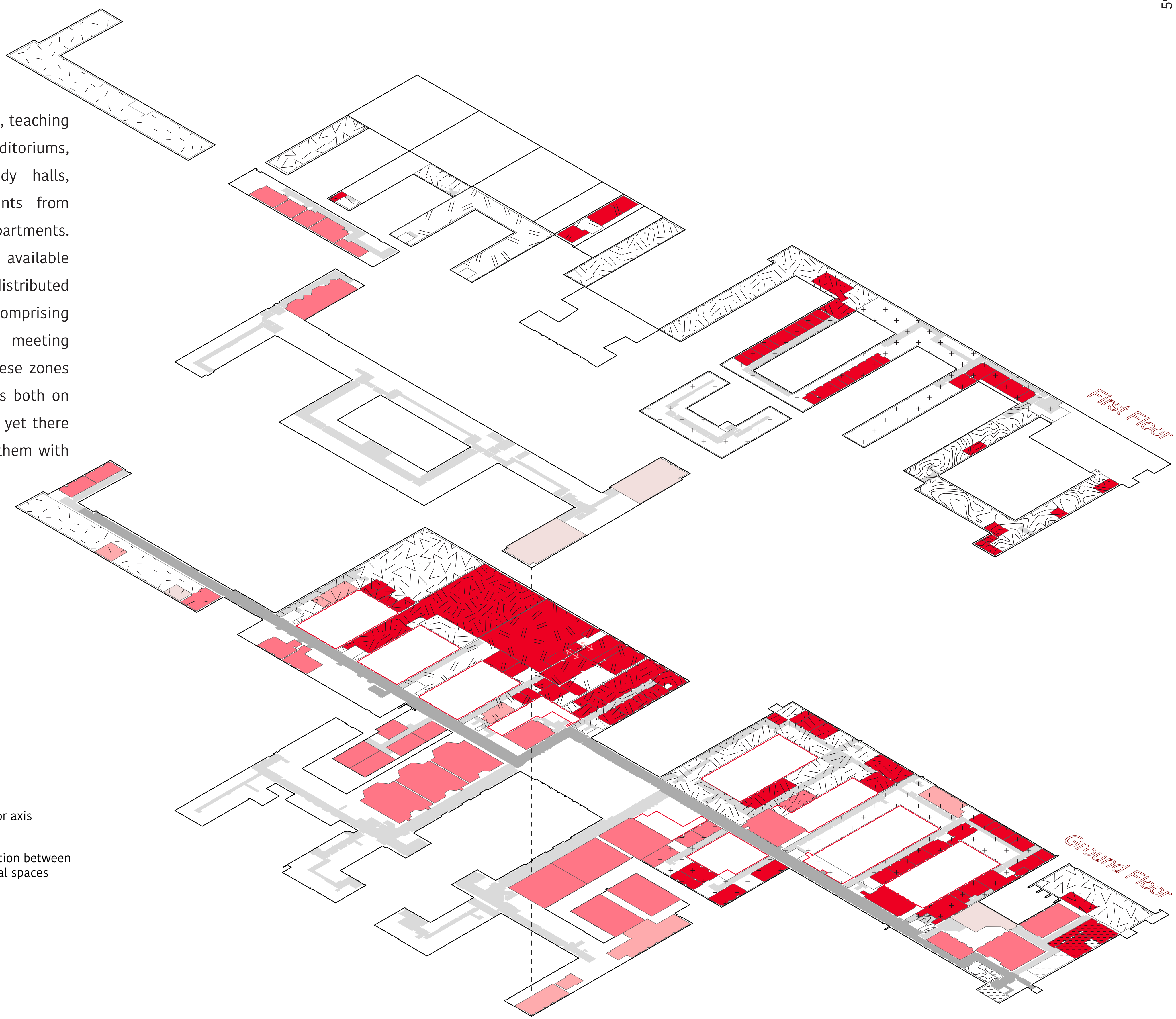
Politecnico di Torino comprises four distinct campuses and 11 departments. The different campuses are home to a variety of departments' teaching and research activities.

The Main Engineering Campus at Corso Duca Abruzzi and Valentino campuses host the departments, and the other two campuses are mainly used for teaching activities for various departments.

DIMEAS	Dept. of Mechanical & Aerospace Engineering
DIATI	Dept. of Environment, Land ,& Infrastructure Engineering
DISEG	Dept. of Structural, Building & Geotechnical Engineering
DIGEP	Dept. of Management & Production Engineering
DISMA	Dept. of Mathematical Sciences
DISAT	Dept. of Applied Science & Technology
DENERG	Dept. of Energy
DAD	Dept. of Architecture & Design
DAUIN	Dept. of Automation & Informatics
DET	Dept. of Electronics & Telecommunications
DIST	Dept. of Science, Planning & Policy of the Territory



On the Main Engineering Campus, teaching and learning spaces, including auditoriums, classrooms, libraries, and study halls, are typically shared by students from the campus's current user departments. However, the research facilities available to the various departments are distributed across several zones, each comprising laboratories, libraries, offices, meeting rooms, and some classrooms. These zones are connected by circulation axes both on the ground and basement levels, yet there is **no interconnection** between them with some exceptions.



As previously stated, the various campuses accommodate different disciplines with their respective teaching and research activities. For instance, the Main Engineering Campus is comprised of teaching environments for the engineering education that primarily consist of classrooms and auditoriums designed for traditional teaching methods, wherein students receive information from instructors in a passive manner, and laboratories are used to put into practice the theoretical knowledge that students got from the frontal teaching. This framework is not suitable for certain educational operations, such as those used by architecture and design departments, even though it might work well for some instructional styles, such as frontal teaching. Such design constraints limit the potential for open-ended discourse and interdisciplinary collaboration, which require adaptable and flexible environments.

This limitation extends beyond the confines of classrooms to encompass other campus areas designated for individual and group study, including study halls and libraries. Those spaces only support a limited methodology of autonomous learning and studying, limiting the students from all the departments use. Consequently, they hinder oppurtunities for students from different disciplines from sharing the common spaces and engaging in their studies.

Image 9. Primary teaching spaces on the Main Engineering Campus

Source: https://www.ansa.it/piemonte/notizie/2021/08/27/politecnico-torino-14-iscritti-ai-test-di-ammissione_006dbe18-a532-47d5-b2a6-eb334d7f39f9.html

- These large spaces (more than 290 m²) are designed exclusively for frontal instruction for a large number of students.
- With the fixed furnitures and the floor being multileveled, the architecture of these classrooms do not offer flexibility for alternative configurations.
- Auditoriums are enclosed by mostly opaque surfaces, cutting off visual connections to the outdoors and nearby spaces.
- The interaction between the students is very limited.

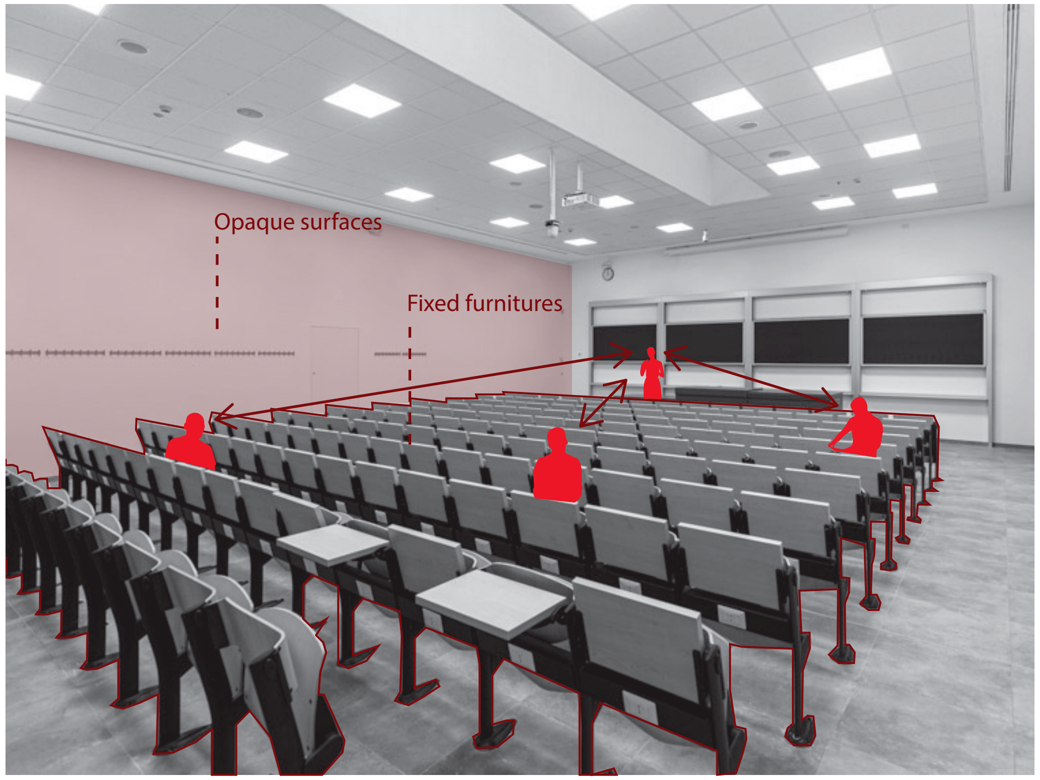


Image 10. Teaching spaces on the Main Engineering Campus

Source: https://www.aresline.com/it/realizzazioni/didattica/politecnico-torino-auler-aule-p

- These spaces are designed exclusively for frontal instruction for a large number of students. (around 150 students)
- With the fixed furnitures, the architecture of these classrooms do not offer flexibility for alternative configurations
- The classroom are enclosed by mostly opaque surfaces, cutting off visual connections to the outdoors and nearby spaces.
- The interaction between the students is very limited.

Image 11. Computer laboratories on the Main Engineering Campus

Source: the author

- The space is primarily used by students to follow instructions and implement them on computers. It is designed to accommodate approximately 35 students.
- The laboratory is enclosed by mostly opaque surfaces, cutting off visual connections to the outdoors and nearby spaces.
- The interaction between the students is very limited.

Image 12. Study room on the Main Engineering Campus

Source: the author

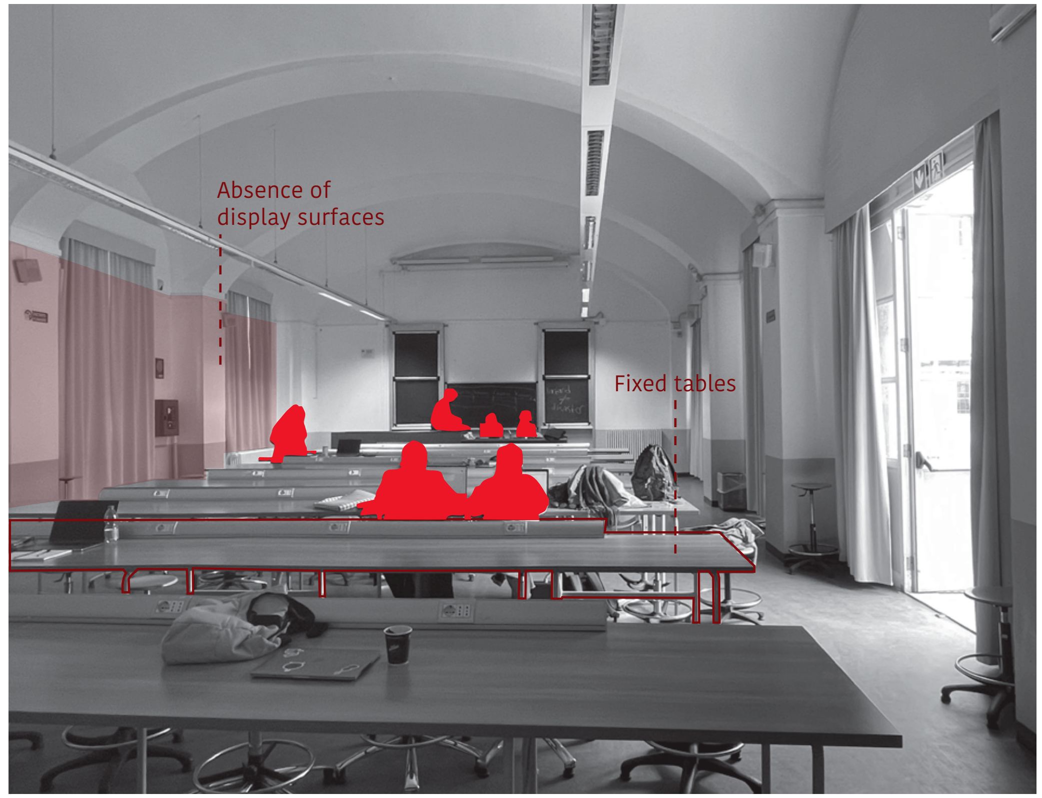


Image 13. Atelier spaces on the Valentino Campus

Source: the author

- The space is primarily designed for autonomous learning.
- Student interaction is very limited, as the environment supports independent work but is not conducive to group collaboration thanks to the seperators on the tables.
- The connectivity of these kinds of spaces to the rest of the learning acitivites is weak due to their location and the surface materials.

- The space (around 180 m²) is primarily used for learning activities within the architecture department, including group discussions.
- It has a capacity of approximately 60 people.
- However, the presence of fixed tables restricts the flexibility needed for alternative configurations.
- Additionally, the space lacks an exhibition area, which is essential for architectural education.

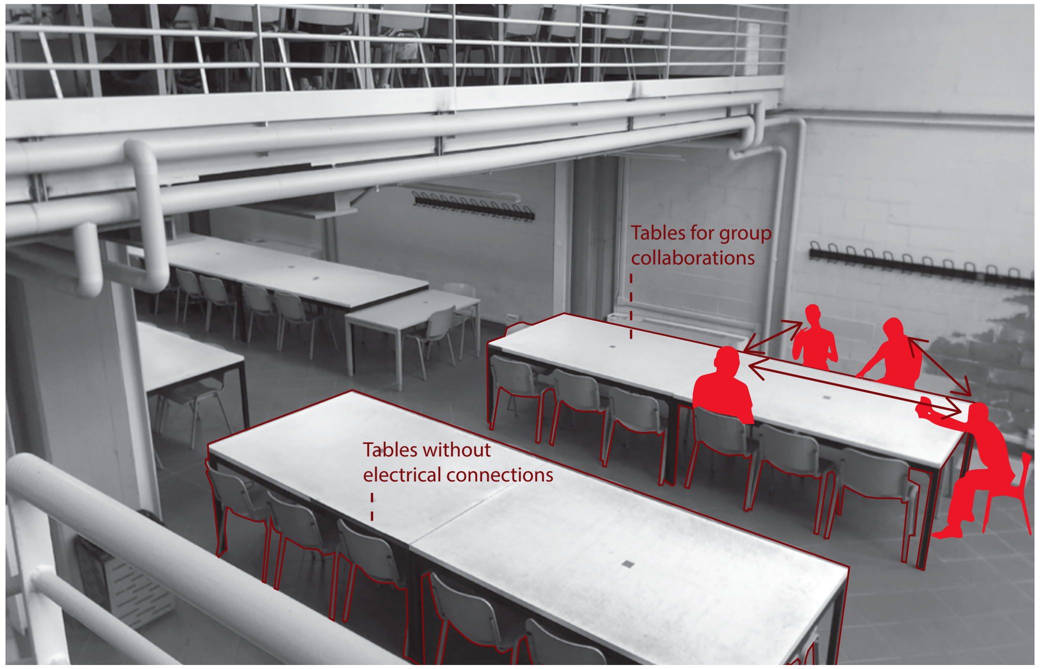


Image 14. Study room on the Valentino Campus

Source: the author

- The space is primarily designed for autonomous learning, with some provision for group collaboration thanks to its design.
- However, as the only study room on campus, it falls short in accommodating more focused, concentrated work.
- Additionally, the space lacks adequate technical infrastructure. The electrical system is only accessible to those seated along the walls, limiting its usability.

Image 15. Atelier spaces on the Mirafiori Campus

Source: the author

- The space is primarily designed for learning activities within the design department, including group discussions.
- It has a capacity of approximately 60 people.
- However, the presence of fixed tables restricts the flexibility needed for alternative configurations.

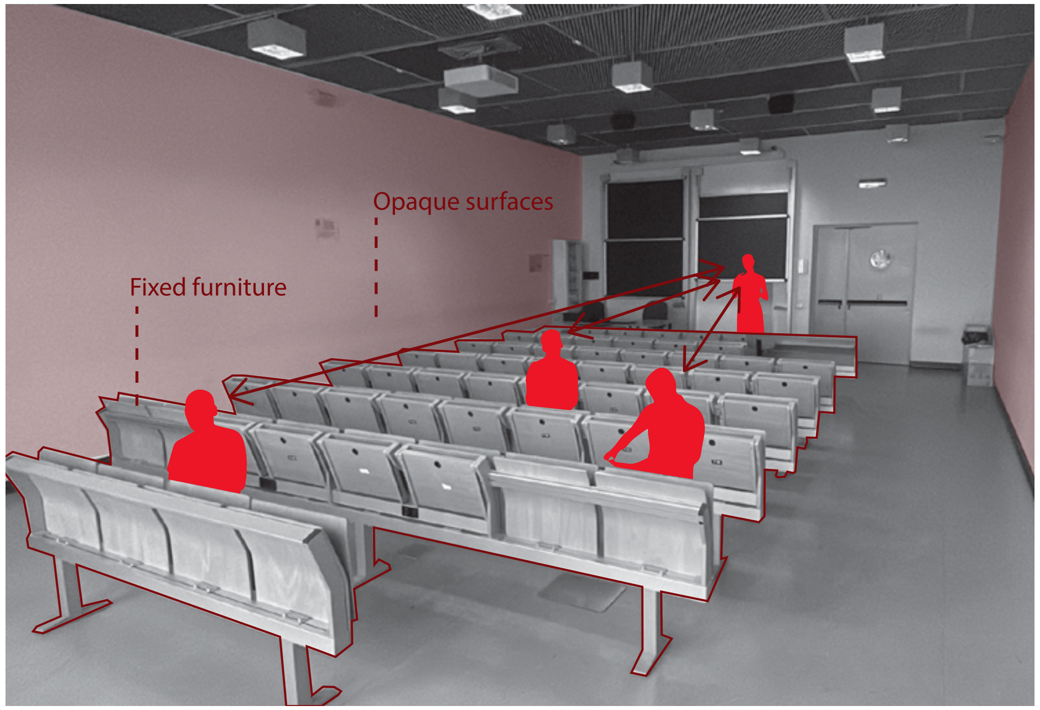


Image 16. Classroom spaces on the Mirafiori Campus

Source: the author

- These spaces are designed exclusively for frontal instruction for a number of students. (around 60 students)
- The presence of fixed tables restricts the flexibility needed for alternative configurations.

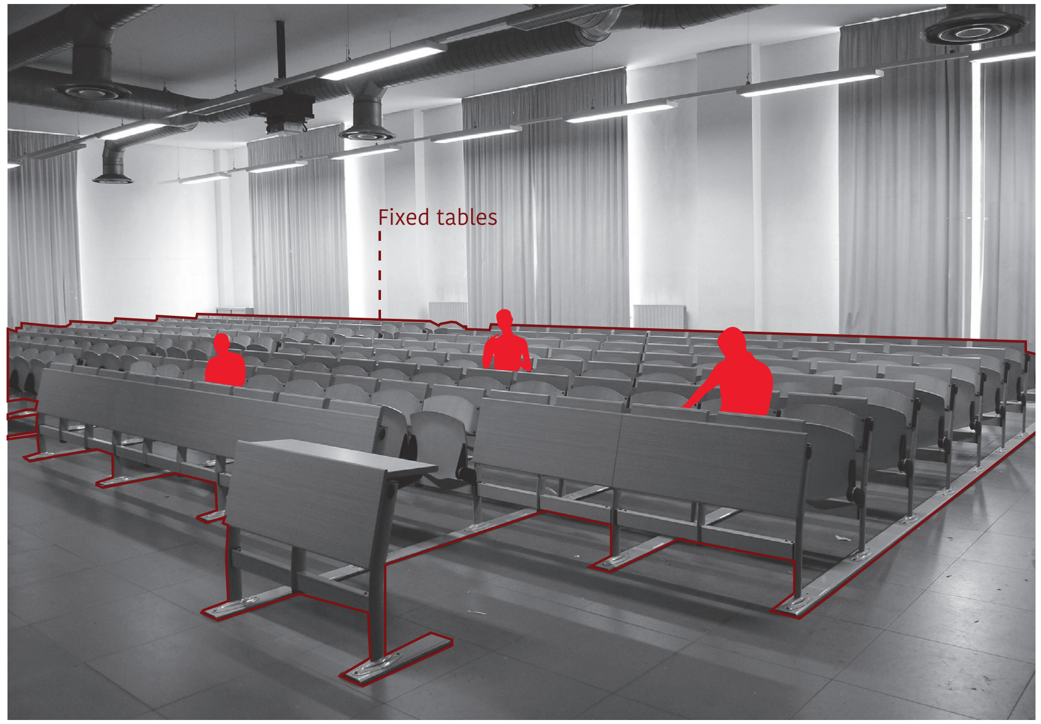


Image 17. Classroom spaces on the Lingotto Campus

Source: https://www.aresline.com/en/projects/educational-environments/politecnico-torino

- These spaces are designed exclusively for frontal instruction for a number of students. (around 230 students)
- These spaces, while ideal for traditional lectures, are not conducive to group collaboration due to the fixed table layout.

The Neglected Collective Spaces: Missed Opportunities for Interdisciplinarity

The modern universities and colleges are gradually becoming less of an assembly of discrete entities and developing into a hub for social interaction and exchange (Hertzberger, 2018). In academic settings, collective spaces are fundamental for promoting interaction and, consequently, interdisciplinarity.

These areas encompass atriums, corridors, additional circulation spaces, courtyards, cafeterias, dining halls etc. According to, Kvavik and Roberts (2009) the outside spaces within the campuses, like patios and courtyards are also effective in fostering interaction and therefore, interdisciplinary collaboration.

These are environments where students and researchers autonomously engage in informal dialogues, practical engagements, and reflective discussions. Moreover, these spaces might be versatile and flexible, often used for purposes which they were not initially designed for. These "third spaces," where students convene for solitary or collaborative study, peer learning, and impromptu idea exchanges, are essential for promoting interdisciplinary interactions.

Students and researchers utilize these places for short durations or extended periods during intervals between sessions, while waiting for the classes to start or while anticipating a meeting with a faculty member. Providing suitable space and by equipping them with

furnishings, incorporating built-in chairs and power outlets, these spaces can motivate students to engage in a fruitful conversation and/or complete their tasks without the need to traverse the campus to reach the library or other designated study areas.

According to Herman Hertzberger and Laurens Jan ten Kate (2018) campuses can encourage socializing activities by creating inviting and attention-grabbing spaces. It is essential to offer users a place that people would naturally pause in rather than just pass through. The focus should be converting traffic - flow spaces to social space. This way, the whole campus setting would turn into a landscape of learning.

These areas, which serve as aesthetically pleasing gathering spots for both formal and informal activities, ought to be situated close to staff offices, classes, and other resources. Knowledge acquisition requires the exchange of experiences and ideas, which can be improved by combining conventional educational environments like lecture halls and seminar rooms with areas for social engagement.

Designing university campuses for improved social interactions of the users necessitates meticulous attention to accessibility and permeability and developing pathways that organically guide individuals around spaces. An integrated circulation system makes it easier to travel about campus and promotes involvement.

Steven Holl Architects designed the Visual Arts Building stairs at the University of Iowa with the goal of promoting informal gatherings, conversations, and exchanges. While some staircases end at spacious landings equipped with tables and chairs, others lead to lounge areas furnished with sofas for informal collaboration.

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Image 18. Staircases in the Visual Arts Building at the University of Iowa

Source: Steven Holl Architects. (n.d.). Visual Arts Building, University of Iowa [Photograph]. Retrieved February 4, 2025, from https://www. stevenholl.com/ project/visual-arts-building-university-of-iowa/

Another example that aims to foster engagement among the members of the interdisciplinary group of researchers is the design of the Lewis Thomas Laboratory. A large staircase utilized by all for vertical movement, featuring spacious landings decorated with art, where individuals can pause to converse (Levine, 1999).

Image 19. The central staircase of the Lewis Thomas Laboratory for Molecular Biology at Princeton University

Source: Collins Jr., J. (1999). The design process for the human workplace [Figure 18.3]. In P. Galison & E. Thompson (Eds.), The architecture of science (p. 409). MIT Press.

At the Main Engineering Campus of Politecnico di Torino, rather than fostering social interaction, the objective of the design of **distributive elements** such as stairways and corridors is limited to facilitating efficient access to various areas.

The **horizontal circulation** is organized along **two principal axes**. The primary axis, together with its extensions, effectively links several department spaces to the main corridor, and this network is largely arranged indoors.

Nevertheless, the secondary axis corridors are **less effective in promoting interaction** among researchers from diverse disciplines. The design does not consider the importance of fostering the kind of casual encounters, teamwork, and impromptu idea sharing that are ,in fact, essential to an educational setting. This design feature reduces the effectiveness of the corridor spaces. Furthermore, the secondary axis is noticeably long, which increases the sense of distance and reduces its potential for frequent use.

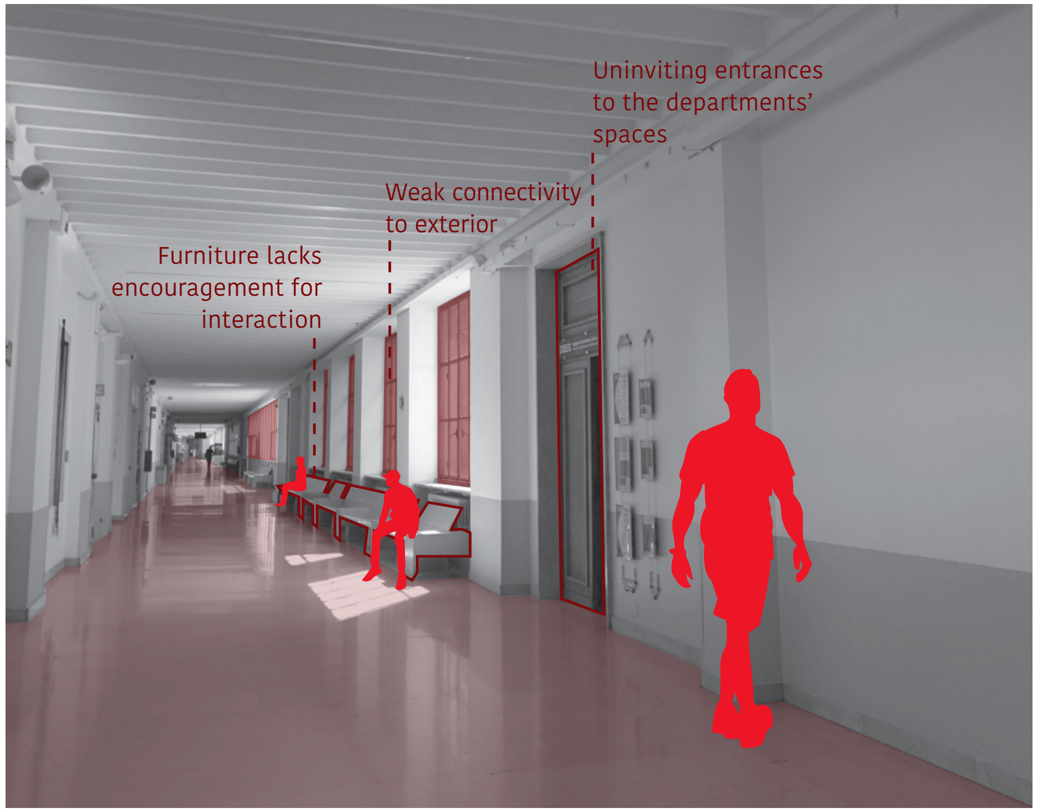


Image 20. Main corridor axis on the Main Engineering Campus

Source: the author

- The visual connection to the exterior is minimal, limiting users' engagement with the surrounding environment.
-
- The design elements, including the furniture, fail to encourage user interaction.
- The connection with nearby spaces is weak, largely due to factors such as the choice of materials.
- The elongated, tunnel-like layout of the space creates a sense of distance, making areas feel inaccessible and less inviting.

Image 21. Corridor on the basement level on the Main Engineering Campus

Source: the author

- The visual connections to the classrooms are very minimal, limiting users' engagement with the activities that are taking place inside.
- It is missing essential design elements, such as versatile furniture, which could easily transform the space into functional learning areas.
- Due to insufficient natural light, the space's potential as an inviting and comfortable learning space is diminished.

Image 22. Vertical circulation spaces on the Main Engineering Campus

Source: the author

- The vertical circulation spaces are generally enclosed, isolated from the rest of the campus.

- They solely function as vertical circulation elements, providing access between floors without facilitating interaction.

Addressing the quality and quantity of common spaces is crucial for enhancing student engagement and collaboration. Collins (1999) argues that architects may effectively encourage the sharing of knowledge through the sharing of space, resources, and facilities by manipulating the frequency of information transmission between researchers and students. By recognizing the role of these gathering places and improving their design, campuses can create more inviting environments that facilitate meaningful interactions among students and researchers from different disciplines.

Despite their importance, the design of the collective spaces are frequently neglected in the campuses Politecnico di Torino, regarding both their accessibility, visibility and the quality of the environment they provide. These shared areas are primarily designed to support the university's core activities which are teaching and research. They are more utilitarian rather than fostering informal interaction, collaboration, or social engagement among students from different disciplines.

On the Main Engineering Campus of Politecnico di Torino, the design reveals a clear distinction between learning and socializing areas, decreasing the potential for serendipitous informal interactions to occur. They primarily represent the institution itself, with large central courtyard and entrance hall that play a prominent role but do not actively engage students. The remaining common spaces such as coffee bars and break spaces often fail to integrate seamlessly with the rest of the academic environment.

A critical observation regarding the collective spaces on the campus is that, even though the complex has a large number of indoor and outdoor spaces for leisure activities they are not used effectively. This can be attributed to many factors. For instance, the accessibility to some of the courtyards solely through the basement level restricts their visibility and connectivity to primary circulation routes on the ground floor. This design feature discourages students from frequently utilizing these spaces, which is problematic considering their potential to promote social engagement.

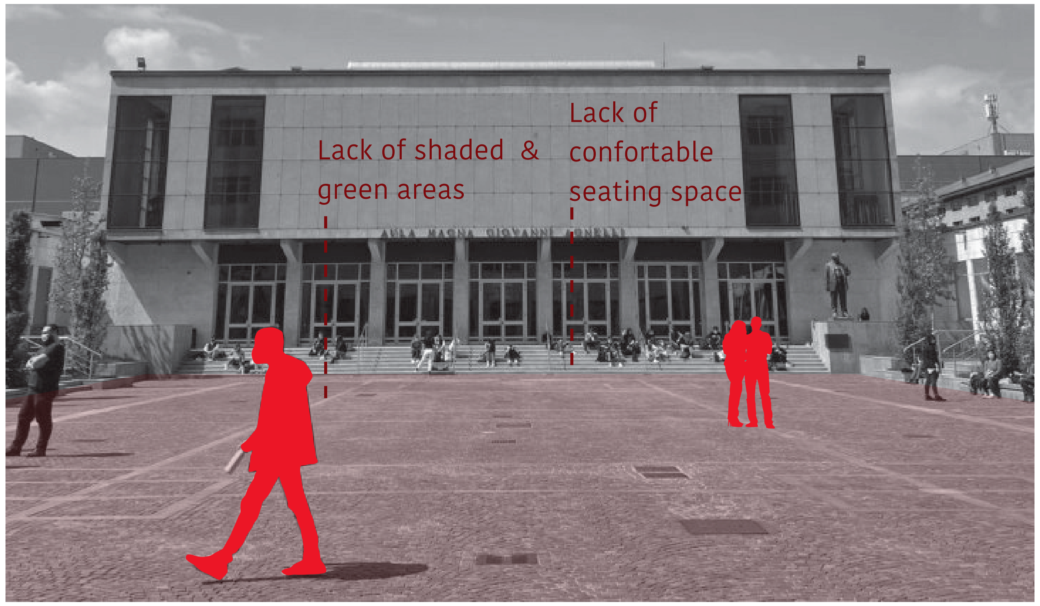


Image 23. Main courtyard on the Main Engineering Campus

Source: https://www.facebook.com/photo/?fbid=10159518549319917&set=a.461435966024875&locale=it_IT

- The courtyard is exposed to harsh weather conditions (e.g., excessive sunlight/ rain) without adequate mitigation, limiting its usability to certain times of the year.
- The design elements, including the furniture, fail to encourage the use of the space.

Image 24. Courtyard between the departmental spaces on the Main Engineering Campus

Source: the author

- The spaces are only accessible at the basement level, which disconnects them from the natural flow of campus life.
- The design lacks inviting gathering areas and fails to provide seamless extensions into the internal learning spaces.

Image 25. Bar Denise on the Main Engineering Campus

Source: the author

- Recreational areas are not well connected to other learning areas and the main circulation axis, which is a lost chance to promote unexpected interactions.

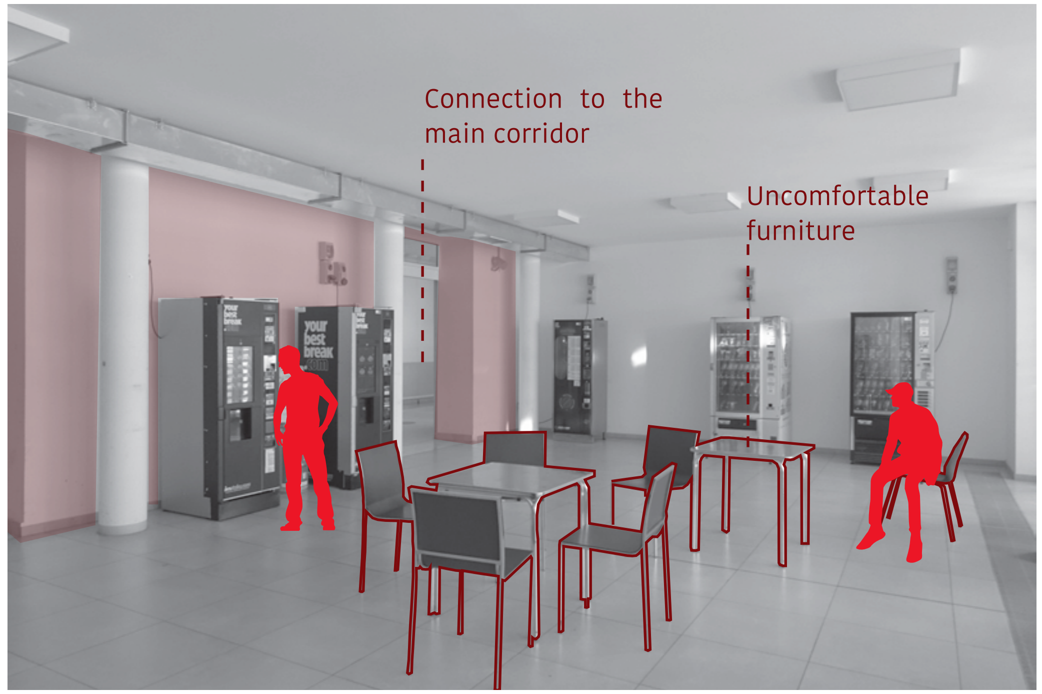


Image 26. Break space on the Main Engineering Campus

Source: the author

- Leisure spaces are poorly connected to the main circulation axis and other learning areas which represents a missed opportunity to encourage serendipitous encounters.

- The choice of furniture does not effectively foster interaction between students and researchers.

III. How Interdisciplinarity is achieved through Spatial Design?

James H. Clark Center : Science on Display

The James H. Clark Center represents a pioneering approach to fostering interdisciplinary collaboration within architectural design. This landmark building is home to Stanford's Bio-X program. This visionary initiative brings together scientists from 23 different university departments from the Schools of Medicine, Engineering, and Humanities and Sciences to address complex scientific and medical challenges. It can hold up to 650-700 people in up to 45 labs, with approximately 20m² useable area per person.

The design philosophy of the Clark Center emphasizes flexibility, adaptability, and openness.

Foster & Partners
Completed in 2003

Image 27. James Clark Center

Source: Karatzas, P. (Photographer). (n.d.). James Clark Center at Stanford University [Photograph]. Divisare. Retrieved February 6, 2025, from https://divisare.com/projects/335589

Spatial Organization

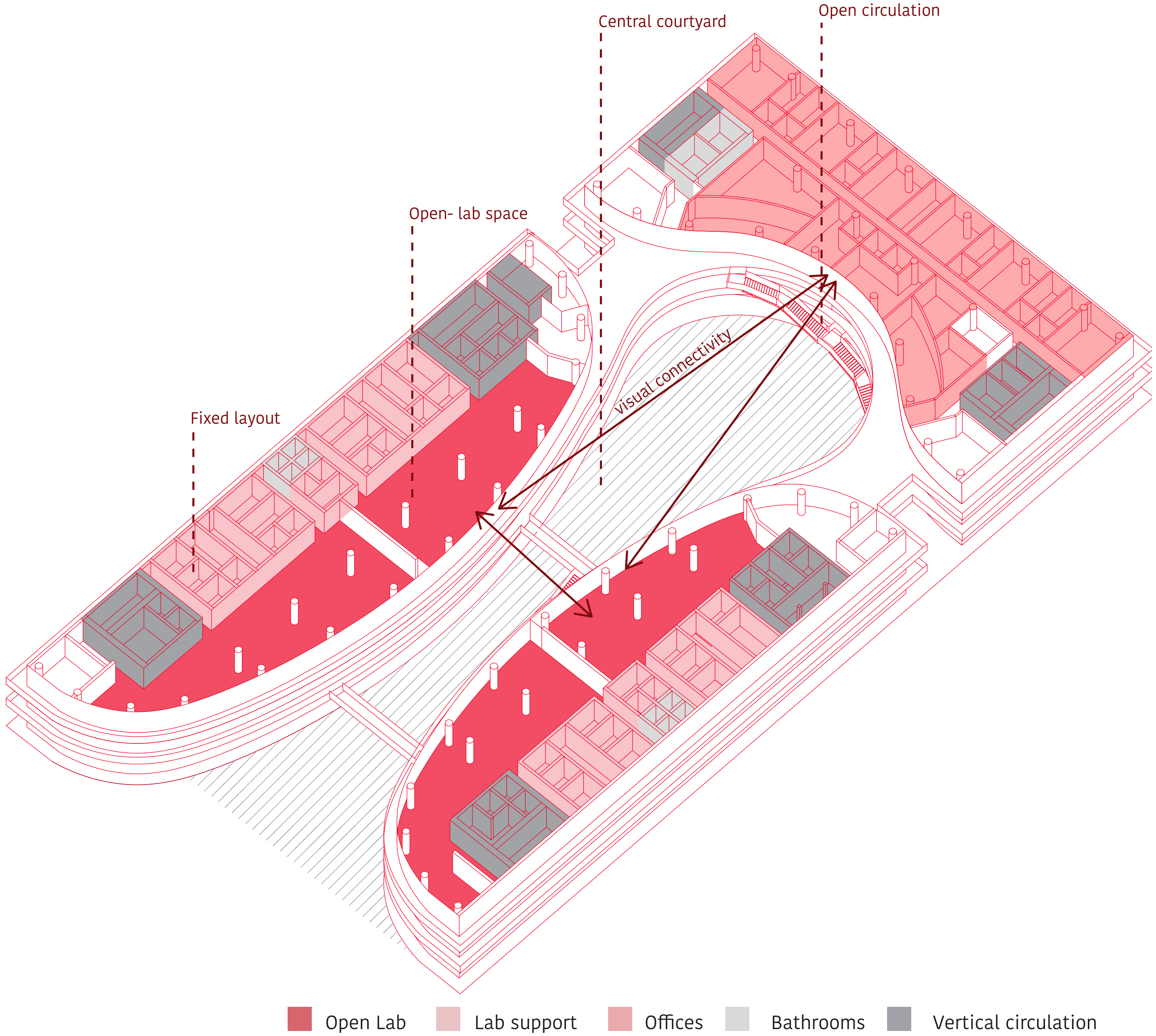
Central courtyard & open circulation spaces are used by every building user; therefore, they are strategically located at the core of the building since these spaces are more likely to encourage spontaneous interactions and informal meetings among researchers from different fields. They are not merely functional but are intentionally designed to foster a sense of community and collaboration among diverse academic communities.

In addition, the spaces between which the collaboration was intended were placed in close proximity to each other. The service cores and the lab support rooms, which are enclosed and fixed, are located in the outer perimeter, where they are more isolated than the rest of the building spaces. Laboratory spaces in various wings are positioned in closer proximity to one another in order to foster engagement.

Flexibility

The building's layout reflects its dynamic purpose. The only areas with a fixed layout are the lab support zones, which offer the necessary infrastructure that remains consistent to support the specific tasks carried out in the labs. The laboratory spaces can be easily adapted thanks to their modular design and flexible floor plans to meet evolving research requirements and promote interdisciplinary collaboration. Researchers can easily modify their workspaces according to changing projects and partnerships by using mobile desks and benches connected to an overhead services system.

The office block spaces can be divided and customized according to the different needs of the occupants.

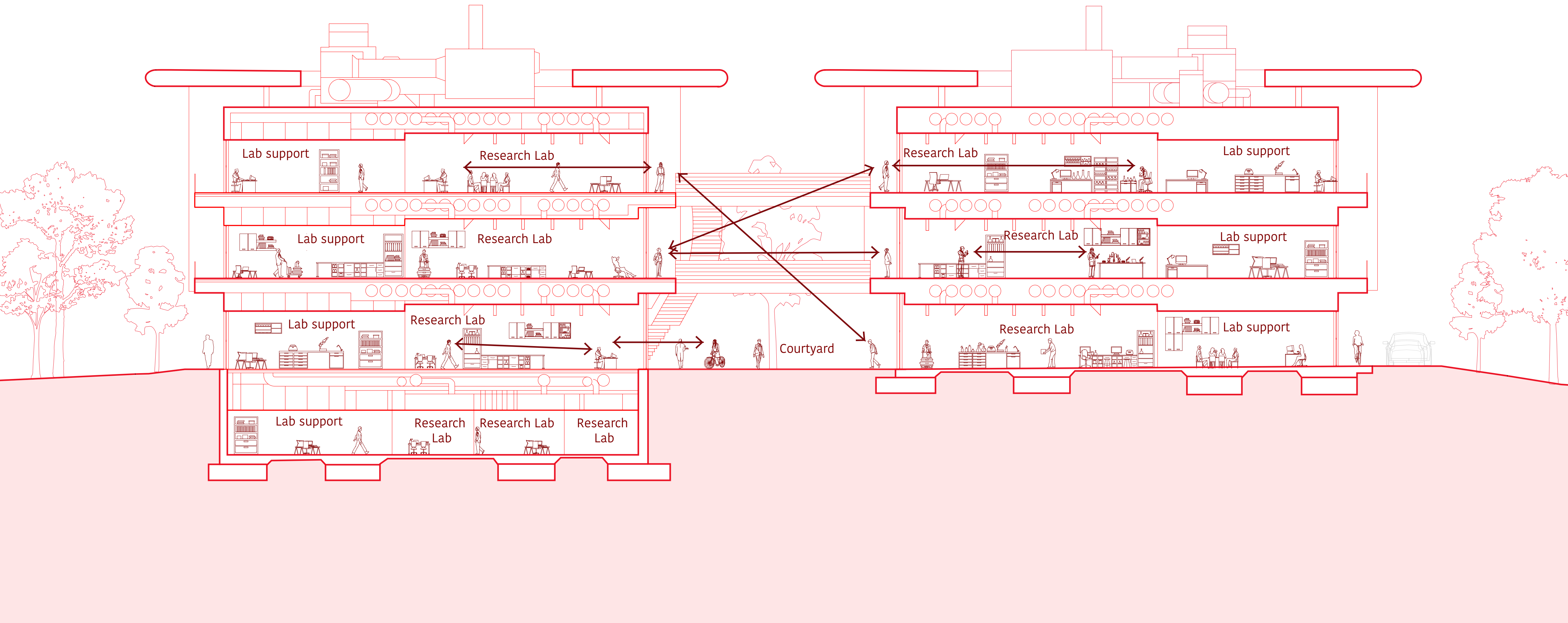


Visual & Physical Connectivity across Floors and with Outdoor Spaces

Two identical lab blocks are mirrored around a central elongated courtyard and flanked by office blocks at either end. The building's two wings are physically connected by bridges, and the laboratories face the courtyard space with their completely glazed curved façade. Possible encounters between scientists from different disciplines are encouraged by these connections and the use of transparent elements as divisions, which ensure that activities inside the building are visible to people outside.

Openness in the Laboratory Space

Beyond its practical features, the center's design is a testament to the breakdown of cultural and physical barriers between academic fields. The facility encourages transparency and visible contact in contrast with typical laboratory facilities, characterized by closed rooms and isolated hallways. By enabling researchers to view and interact with one another's work, this architectural decision not only fosters collaboration but also stimulates interest and interaction from guests and bystanders.



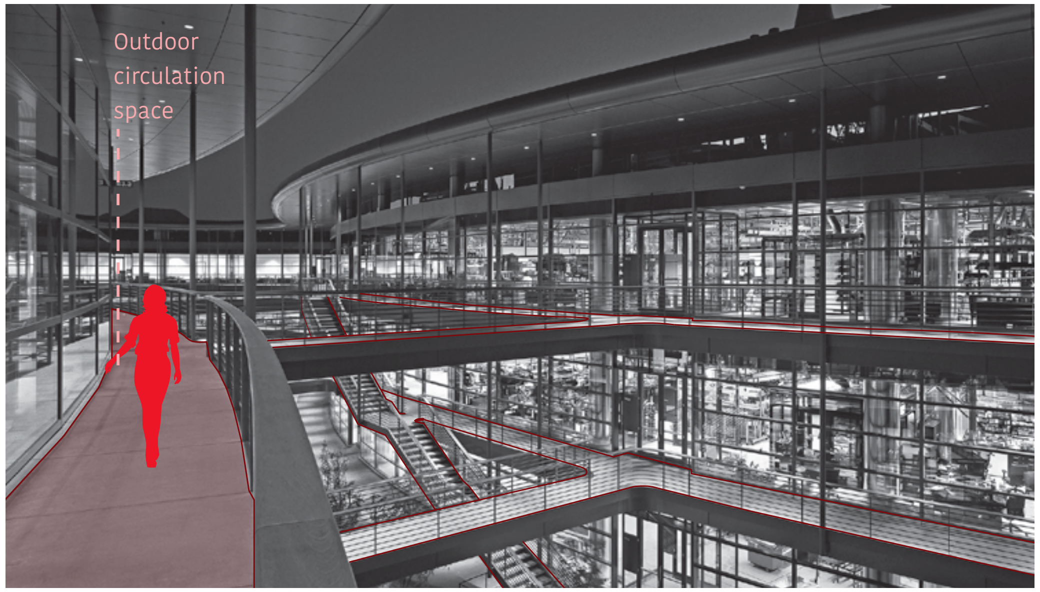


Image 28. Image showing the open circulation space

Source: https://www.fosterandpartners.com/projects/james-h-clark-center-stanford-university

Image 29. Image showing the open-lab space

Source: https://www.fosterandpartners.com/projects/james-h-clark-center-stanford-university

Shortcomings

Although through the design elements such as openness, transparency, and flexibility that are integrated into Foster + Partners' architectural design for the James Clark Center successfully encourage teamwork and interdisciplinary engagement, some design elements may compromise usability or functionality.

- Although adaptability and transparency encourage teamwork and creativity, they also pose difficulties in preserving consistent climatic conditions and managing noise levels across the labs.

- It might be particularly challenging to maintain targeted humidity, temperature, and air circulation for certain research areas within an open floor plan.

- Equipment that is sensitive to temperature and humidity may have trouble being placed on the fully open, floor-to-ceiling glazed floor plate because of possible temperature and humidity variations.

Zollverein School of Management & Design: Seamless Spatial Integration

It is a research and educational institution with an interdisciplinary educational program that combines corporate management enablement with developing creativity. (Baletic et al., 2017) The structure itself is designed to foster openness and flexibility.

SANAA
Completed in 2006

mage 30. Zollverein School of Management & Design

Source: Hjortshøj, R. (Photographer). (n.d.). Zollverein School of Management and Design [Photograph]. Divisare. Retrieved February 6, 2025, from https://divisare.com/projects/349308

The open-plan design

The floors of the building, especially the studio sections, are large, open spaces absent of conventional partition walls that provide a great deal of flexibility for both teachers and students. Movement and contact among various academic groups and specialties are encouraged by this absence of space division. This supports the unrestricted movement and user-defined places tenets of SANAA, which promote innovation and teamwork. Because academics and students are not restricted to separate spaces or departments, spontaneous cooperation and collaborative initiatives are encouraged. This arrangement makes it easier for people from many fields, like management, design, and the creative arts, to collaborate and share ideas.

The ground floor functions as a public venue for exhibitions and events, but the second floor provides an expansive studio space suitable for collaborative activities. The open plan enables students from different disciplines to work together on common tasks, configure the space as they need, and, as a result of these, helps to promote interdisciplinary collaboration.

Transparency

There is an emphasis on the transparency within the design of the building. The frequent use of glass partitions instead of opaque walls facilitates visibility across spaces. The design encourages curiosity and creates chances for interdisciplinary dialogue by making it possible for individuals from various departments or disciplines to witness what others are working on.

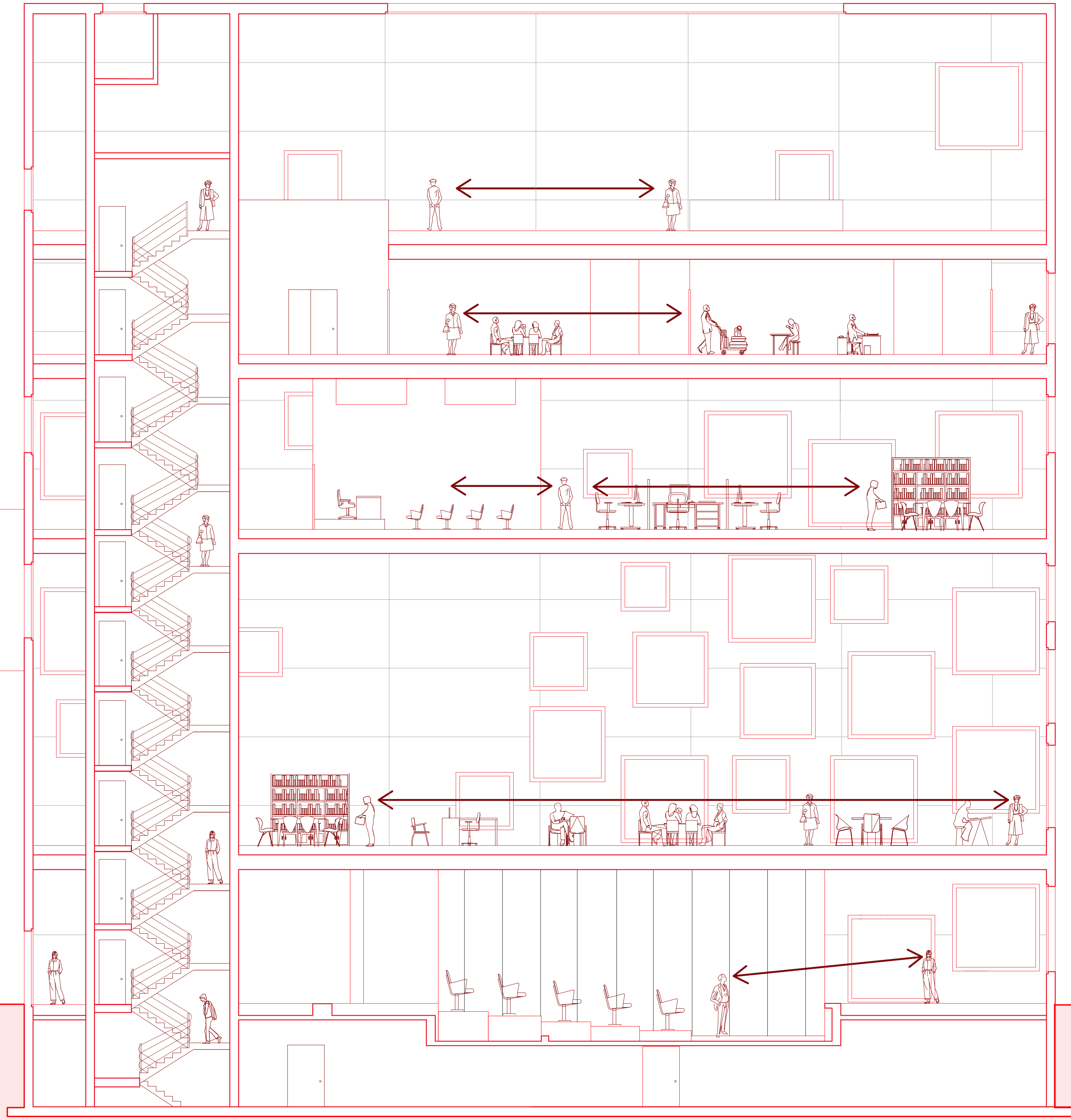


Image 31. Image showing the exhibition space

Source: https://www.archdaily.com/801825/sanaas-zollverein-schoolof-management-and-design-photographed-by-laurian-ghinitoiu/58583 ae2e58ecebf57000766-sanaas-zollverein-school-of-management-anddesign-photographed-by-laurian-ghinitoiu-photo

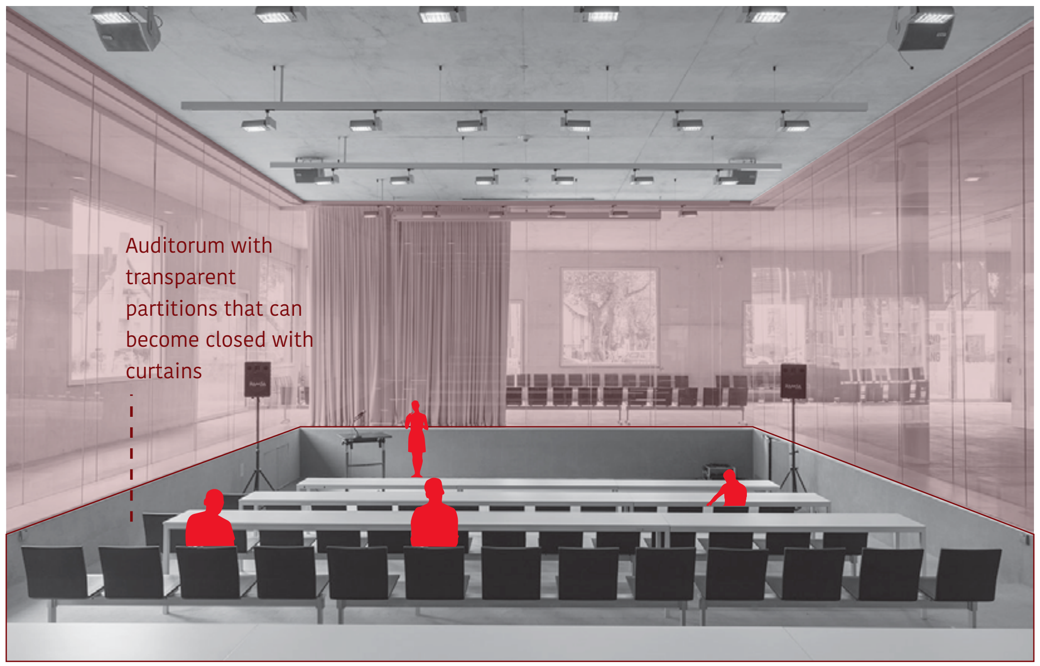


Image 32. Image showing the auditorium space

Source: https://www.thisispaper.com/mag/zollverein-school-ofmanagement-and-design-by-sanaa

Shortcomings

Thanks to its unconventional spatial design, the Zollverein School of Management and Design by SANAA, is one of the most excellent examples of architecture for interdisciplinary education and research. Nevertheless, some of the design choices that foster openness and flexibility—key principles in the design of the building—can present some challenges to its overall functionality.

- The building does not offer much space for the concentrated work since there are a limited number of enclosed spaces that are free of distractions. The avoidance of having enclosed spaces, on the other hand, contributes to the primary goal of the building, which is to accommodate interdisciplinary collaboration and flexibility in design.

- Because there are few partitions, noise control problems could occur depending on the different activities.

- The connectivity between different floors is weak. Moving between floors is only possible via the enclosed stairway.

MIT Media Lab:
Network of Interconnected Spaces

Fumihiko Maki's design for the MIT Media Lab building in the late 1990s was a pivotal response to the evolving challenges and aspirations of interdisciplinary education and research. His approach embodied the principles of integration, flexibility, and longevity in architectural design. Maki's architectural language for the MIT Media Lab was characterized by transparency & adaptability.

Fumihiko Maki
Completed in 2009

Image 33. MIT Media Lab

Source: LWA Architects. (n.d.). MIT Media Lab [Photograph]. Retrieved February 6, 2025, from https://www.lwa-architects.com/project/mit-media-lab/

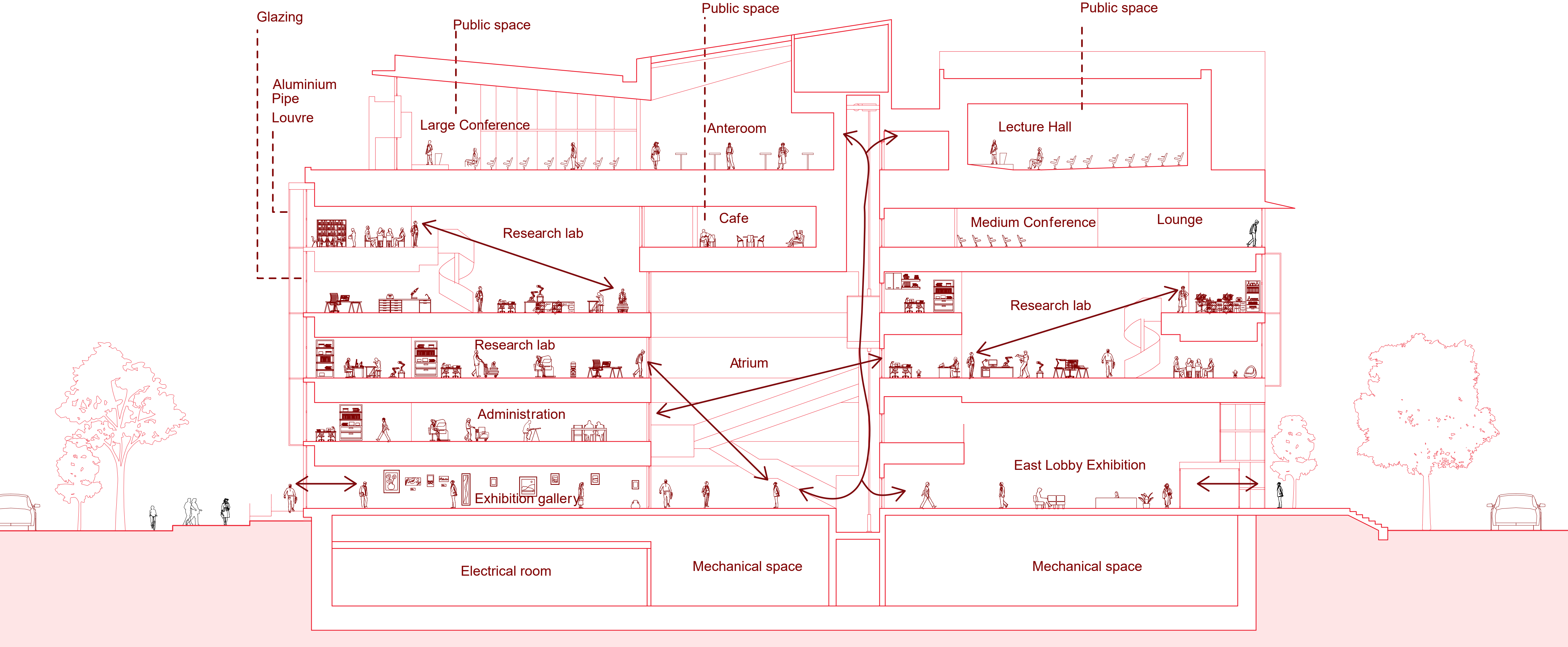
Connectivity within the Building & with the Outside Environment

The building's exterior featured a curtain wall, augmented with external aluminum screens for sun control and a distinctive visual rhythm. This not only allowed for ample natural light but also contributed to showcasing the people outside the ongoing work.

As Mitchell (2007) noted, Maki's approach reflected a keen understanding of human-centric design principles. By placing public and communal spaces, such as auditoriums, meeting and event spaces, and a café, on the upper floors, the design draws visitors up through the vertically stacked, transparent laboratory spaces and makes the ongoing work made visible.

The layout eschewed traditional compartmentalization in favor of interconnected spaces. The design encouraged visual and physical connectivity between different floors and departments, fostering a sense of openness and shared purpose.

Spaces have transparent edges providing horizontal vistas to the exterior. The design incorporates vertically offset research labs, creating long sightlines through the building, allowing researchers to see across different levels. This way it fosters a sense of community and constant engagement.

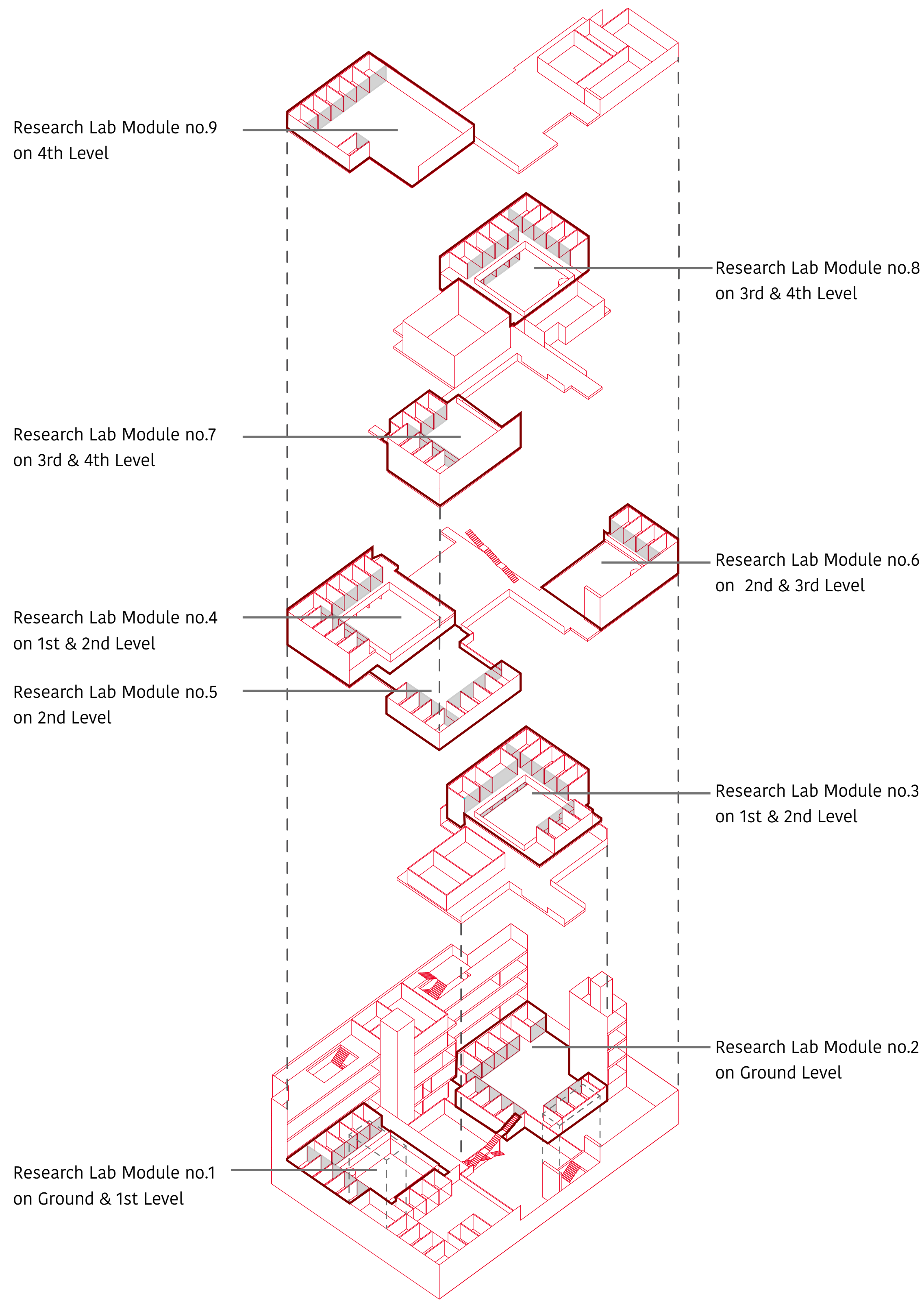


Versatility of Spaces

Research laboratory spaces have a modular design that is repeated throughout the building but varied in its spatial qualities. Different variations of the lab modules on different floors offer different qualities of spaces for different functions that are taking place within.

Functional Ambiguity

Laboratory spaces do not respond to a specific program, as is the case with traditional research centers. While designing the building, what was central to Maki's philosophy was the notion of creating a space that could accommodate the dynamic and unpredictable nature of technological advancements and research agendas in order to make the building time-proof. Unlike traditional architectural approaches that prescribe rigid layouts based on immediate needs, Maki envisioned a building that could evolve over time. In MIT Media Lab, the lab modules consist of open lab space surrounded by rectangular, enclosed labs, which makes them program-free. The design of the building carefully avoids dependence on technologies and assumptions that may become obsolete but attempts to respond sensitively to basic human needs and desires that never change. With some necessary exceptions, laboratory and faculty office spaces do not respond to a specific program; no names indicate specific uses of laboratory spaces on the drawings.



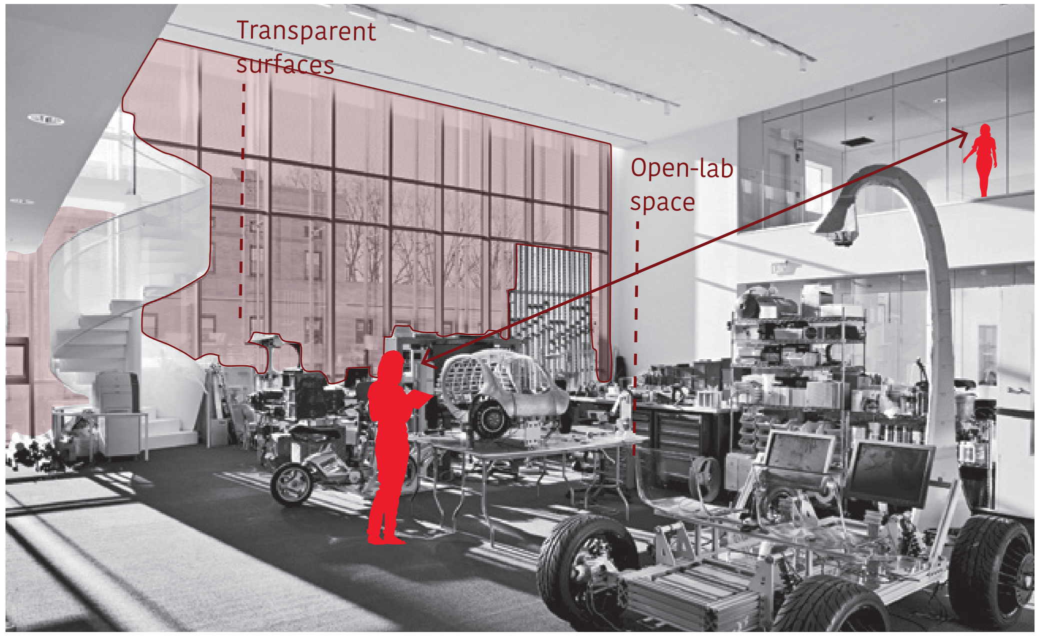


Image 34. Image showing the laboratory space

Source: https://www.lwa-architects.com/project/mit-media-lab/

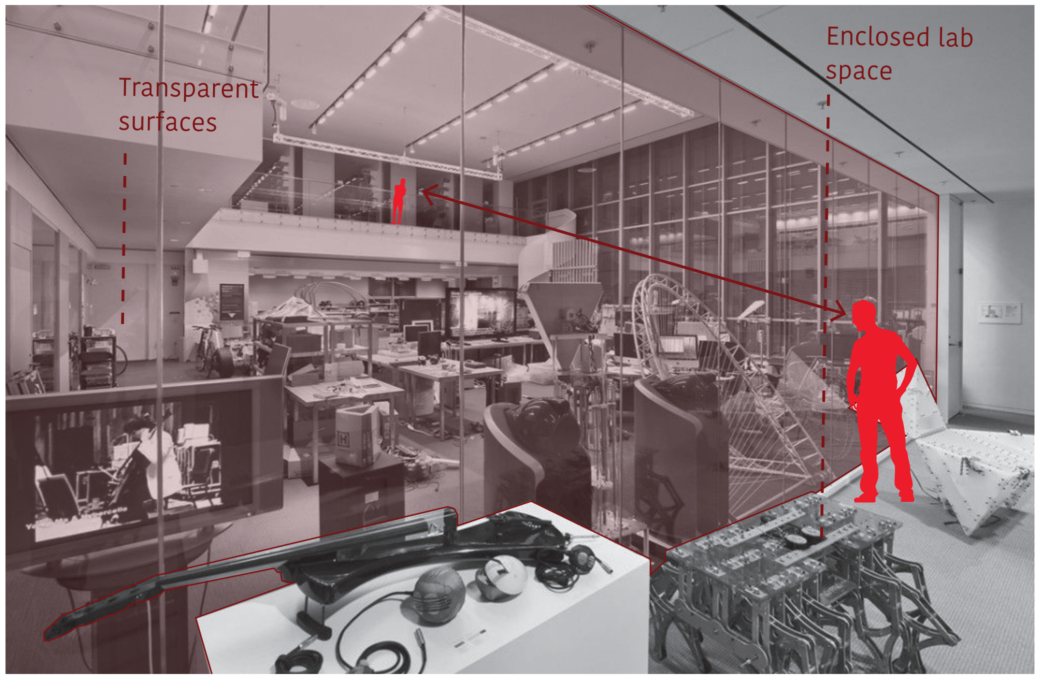


Image 35. Image showing the laboratory space

Source: https://www.lampartners.com/projects/mit-media-lab-4/

Shortcomings

Although Fumihiko Maki's MIT Media Lab building effectively promotes interdisciplinary collaboration between the researchers working on different topics, there are a few possible design issues that can have a negative effect on the building's functionality or user experience:

- The open layout that promotes interdisciplinary collaboration comes at the expense of areas meant for in-depth, concentrated study.

- It can be challenging for students or researchers to concentrate on tasks requiring deep concentration because of noise and distractions, even though the open-plan layout and glass partitions make a visually pleasing setting that encourages teamwork.

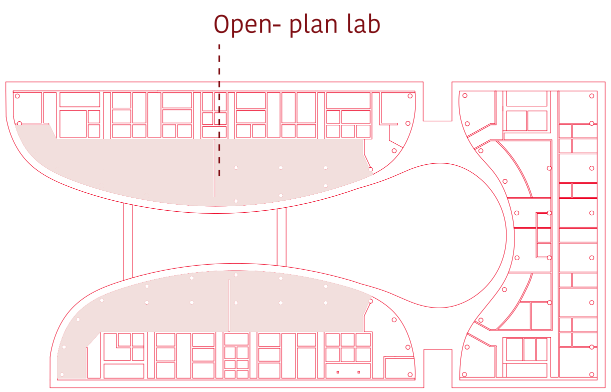
The Architecture of Collaboration: Findings from Case Studies

The analyzed buildings all serve the purpose of accommodating people working in different disciplines. It is evident that all three examples share a common goal of flexibility of spaces and fostering interactions among the users of these spaces. Various strategies are employed to achieve these objectives, with some recurring across multiple buildings.

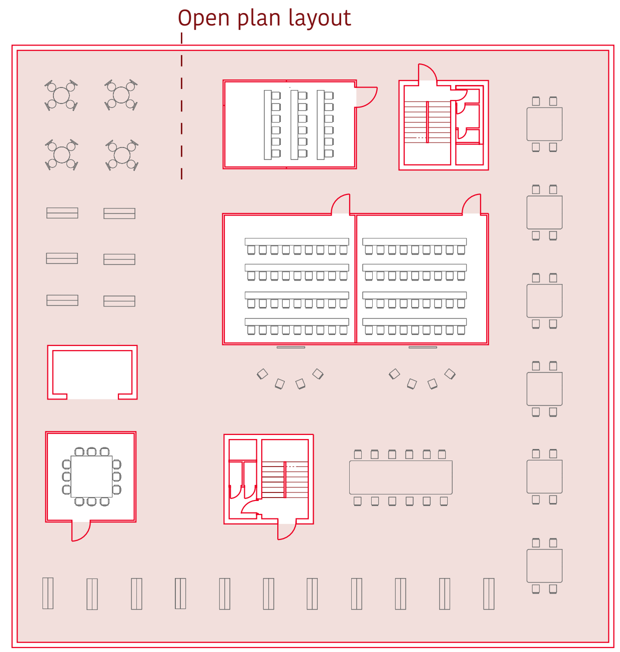
Flexibility

Flexibility is a crucial design strategy in creating interdisciplinary working environments since the spaces should be available to be easily modified in order to accommodate the changing needs of different disciplines' activities.

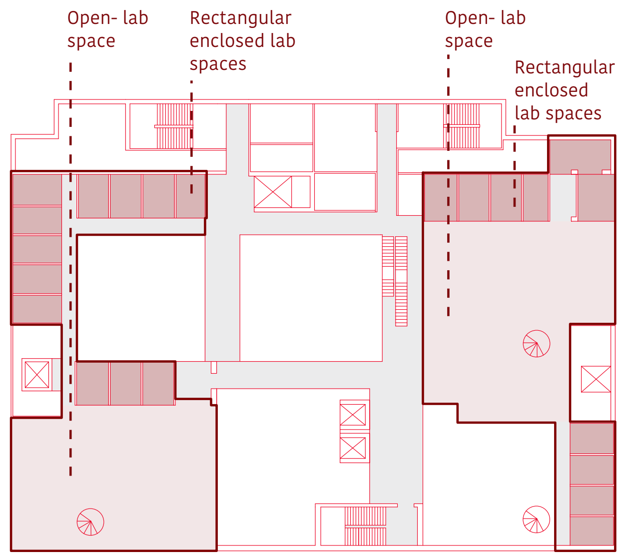
In the James Clark Center, use of open lab space with workstations that plug into an overhead system of services helps the users to use the space as the activities taking place require.



In the Zollverein School of Management & Design, designers employed an open-plan design to provide users with the flexibility to adapt the space according to their specific activities and requirements and also help with fostering social interaction.



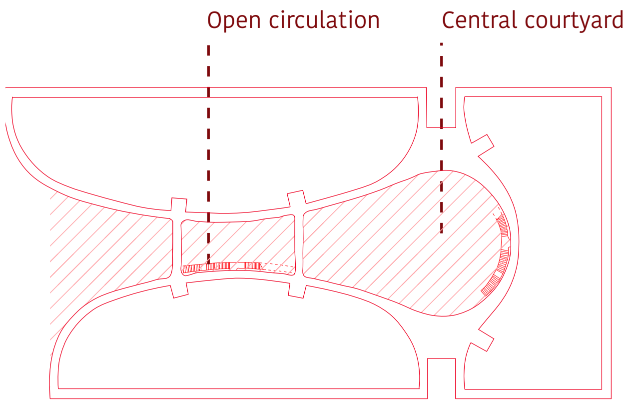
In the MIT Media Lab, the lab modules consist of open lab space surrounded by rectangular, enclosed labs, which makes them program-free and adaptable to the dynamic and unpredictable nature of technological advancements and research agendas.



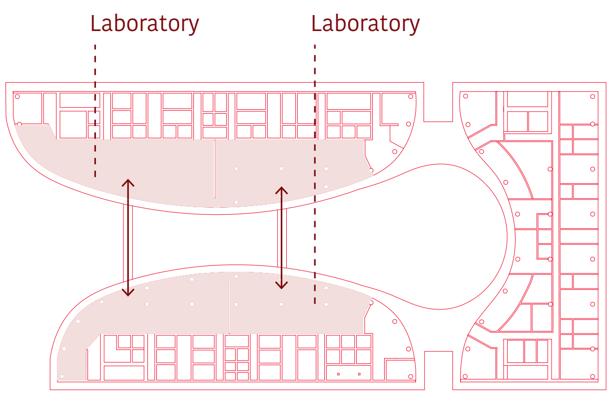
Sociopetal Design to Encourage Collaboration

Through sociopetal design, institutions can facilitate the interaction of students and researchers from different disciplines that yield innovative ideas and fruitful interdisciplinary collaborations.

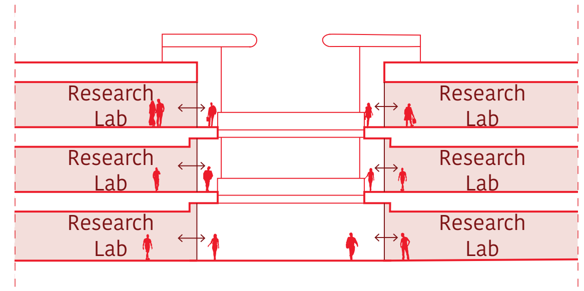
In the James Clark Center, the courtyard and main circulation spaces are strategically located at the building's core. This way, the design ensures that these spaces contribute to fostering interaction due to their frequent use by the building occupants.



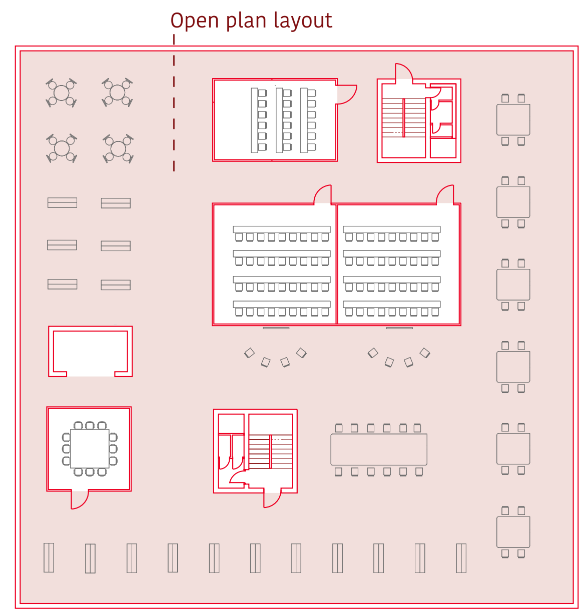
In the James Clark Center, spaces dedicated to collaboration are intentionally located in close proximity, enhancing the likelihood of serendipitous encounters among scientists and further promoting a culture of interdisciplinary collaboration and engagement.



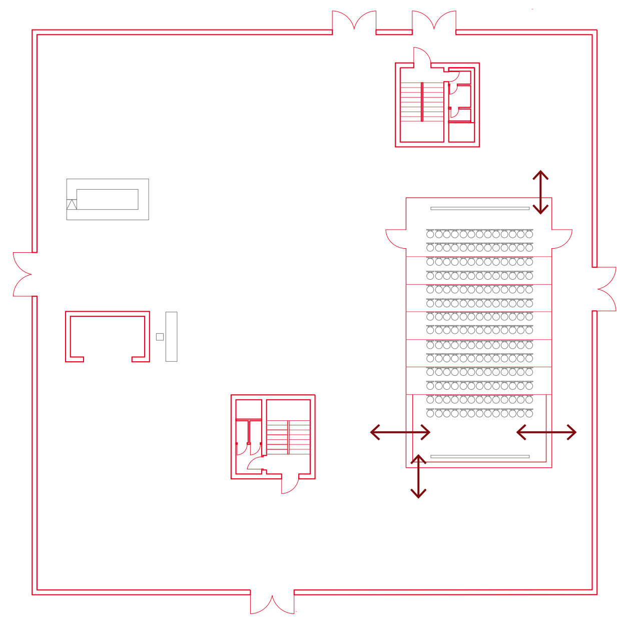
In the James Clark Center, in order to showcase the activities inside the research labs, a glazed façade was integrated into the design. By putting science on display, this design feature fosters interaction between those inside and passersby outside.



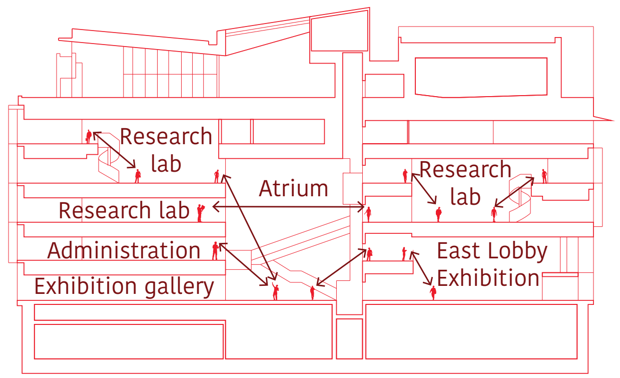
In the Zollverein School of Management & Design, the open-plan layout eliminates the partitions and helps with fostering social interaction and encouraging seamless engagement among users.



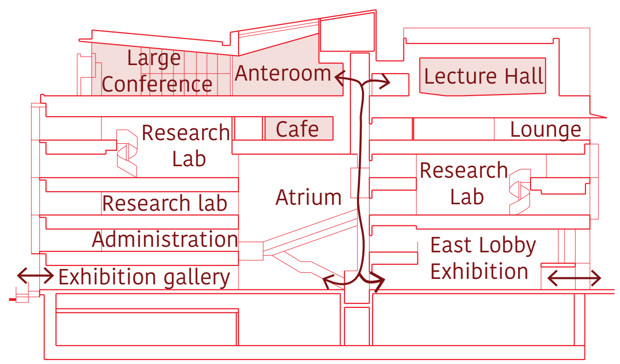
In the Zollverein School of Management & Design, the enclosed spaces have clear partitions to allow interaction with the outside.



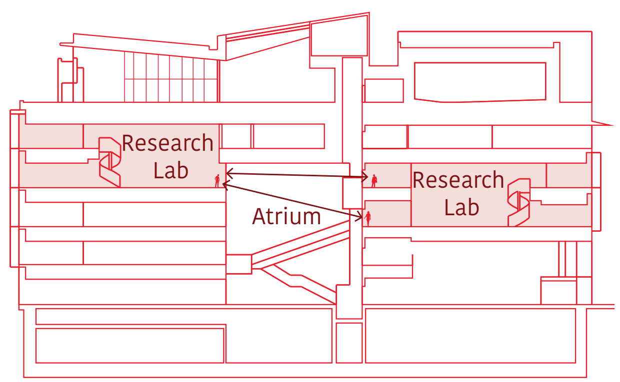
In the MIT Media Lab, the design features atriums to create both vertical & horizontal vistas to encourage interaction.



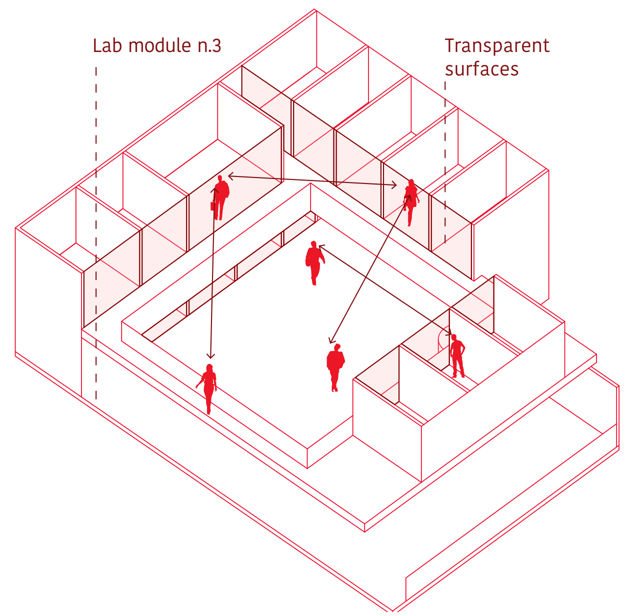
In the MIT Media Lab, public spaces were placed thoughtfully on the upper floors of the MIT Media Lab in order to encourage guests to explore the whole building and observe the research activities inside before arriving at their destination.



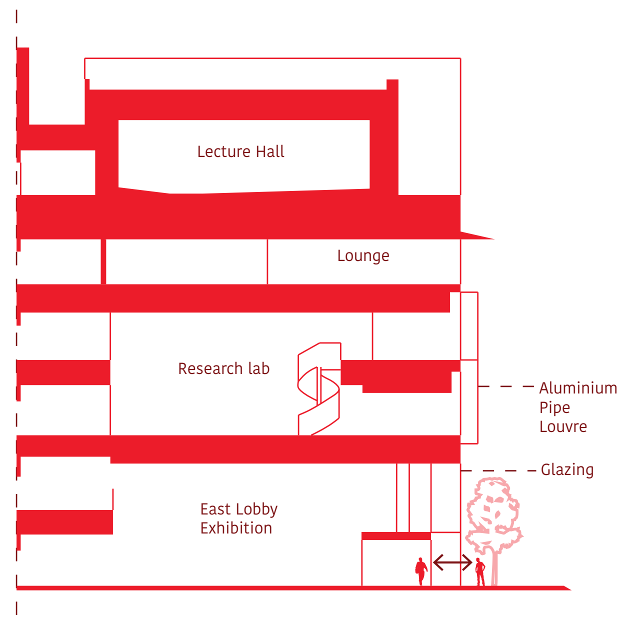
Within the MIT Media Lab, extended sightlines were created by using vertically offset lab spaces, which enabled visual connectivity throughout the structure.



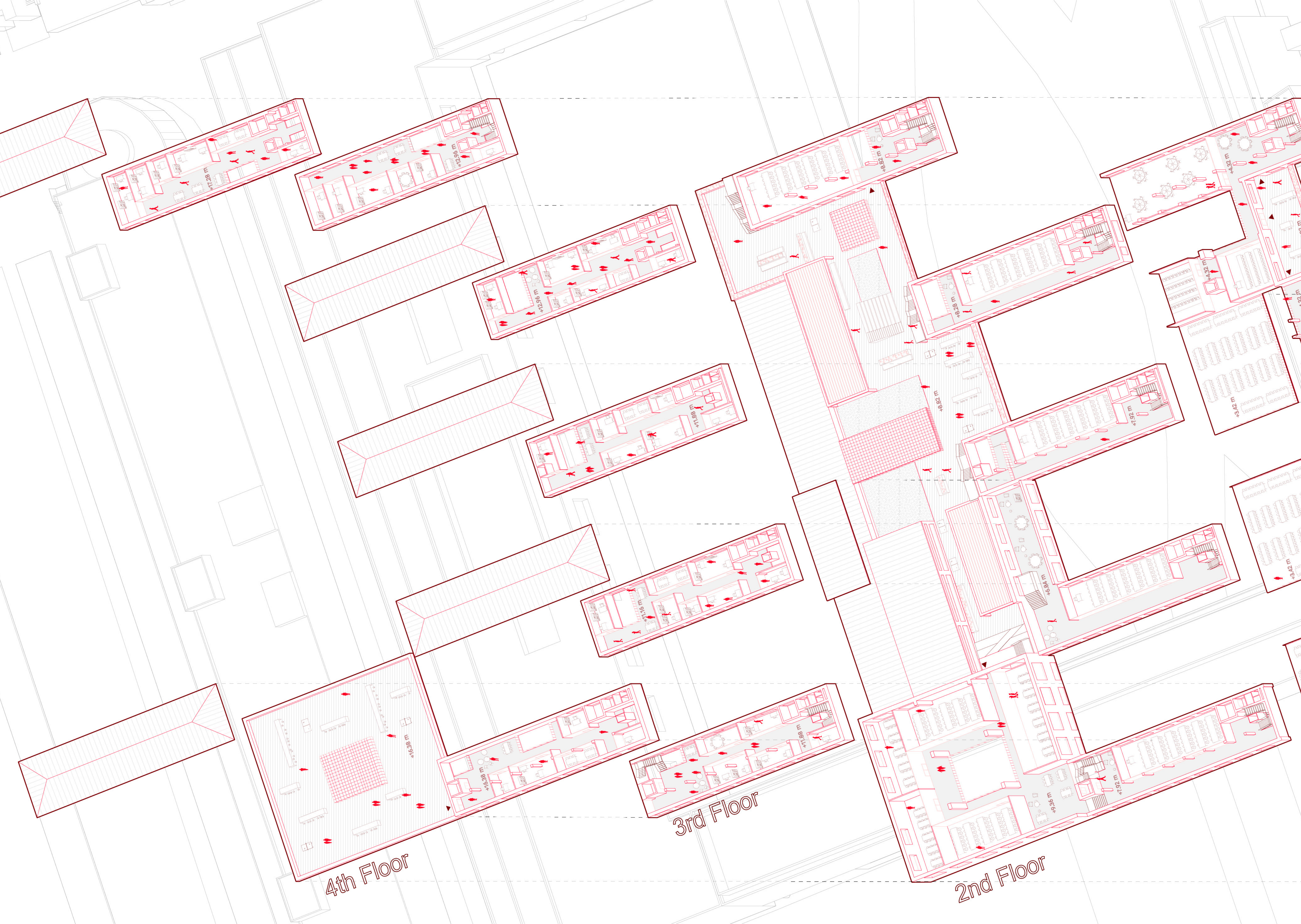
Within the MIT Media Lab, laboratory modules feature transparent partitions that enable the researchers to maintain visual connections and interact with each other, even while working within enclosed spaces.



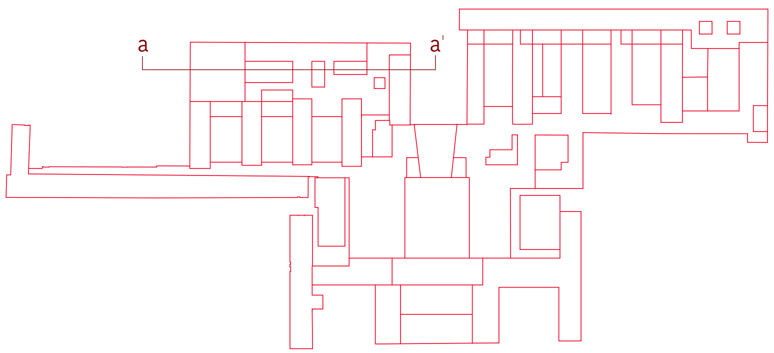
The MIT Media Lab building features a transparent façade to showcase the activities inside. This design choice offers the public display of science for the passersby.

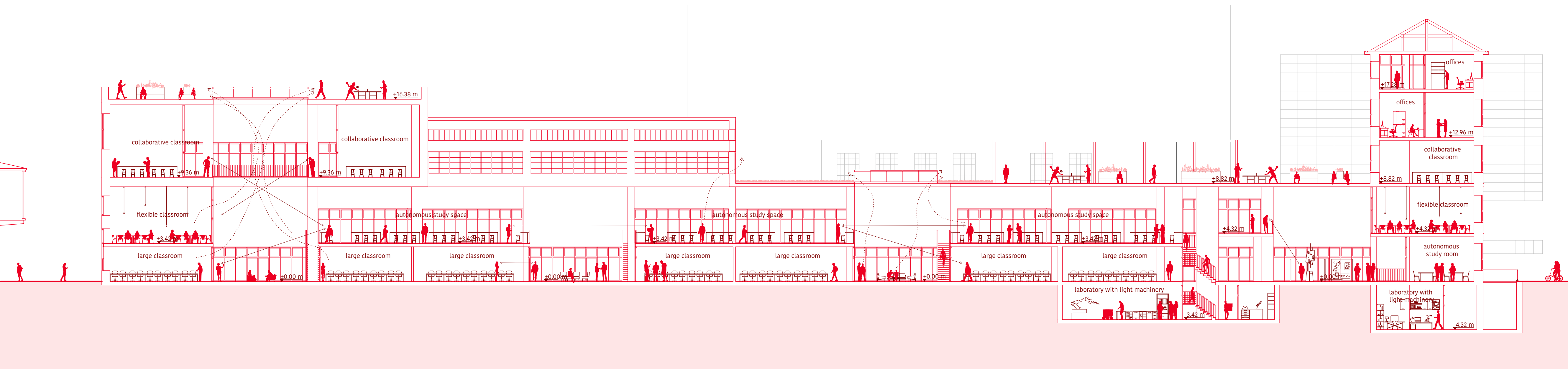


IV. Breaking Down the Departmental Silos


4th Floor
3rd Floor
2nd Floor


1st Floor
Ground Floor
Basement Floor
+3.96 m
+3.06 m
+3.42 m
± 0.00 m
-3.42 m
-3.96 m

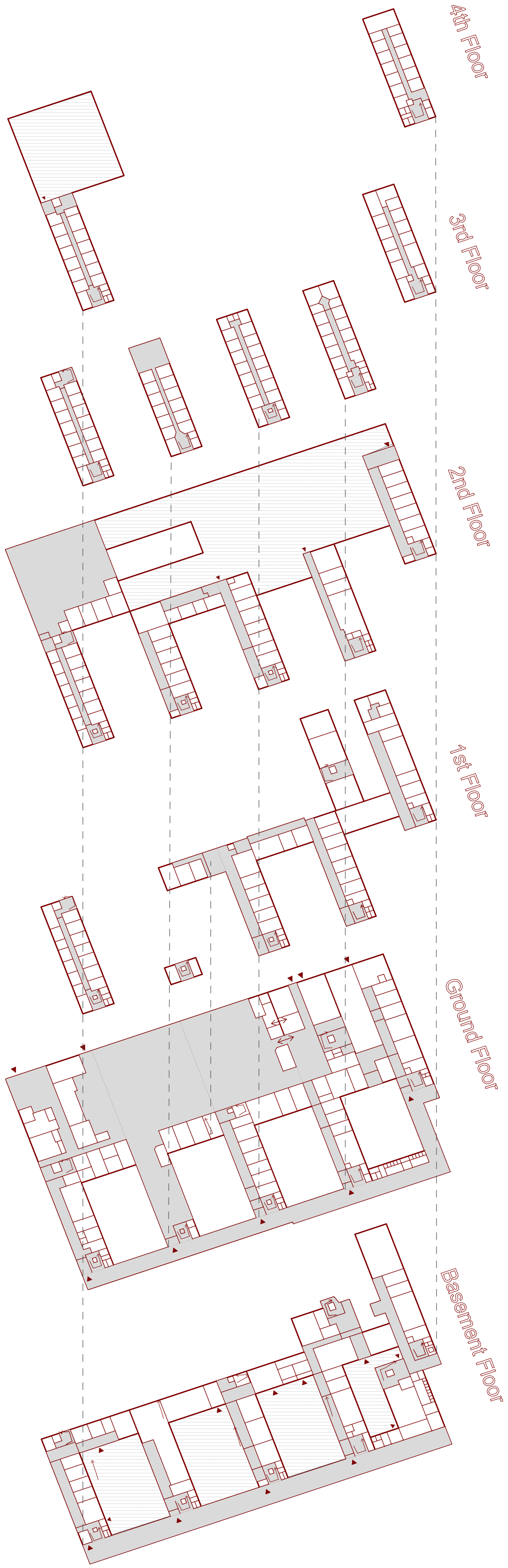




Longtitudunal Section

Scale : 1/400

Existing Spatial Organization



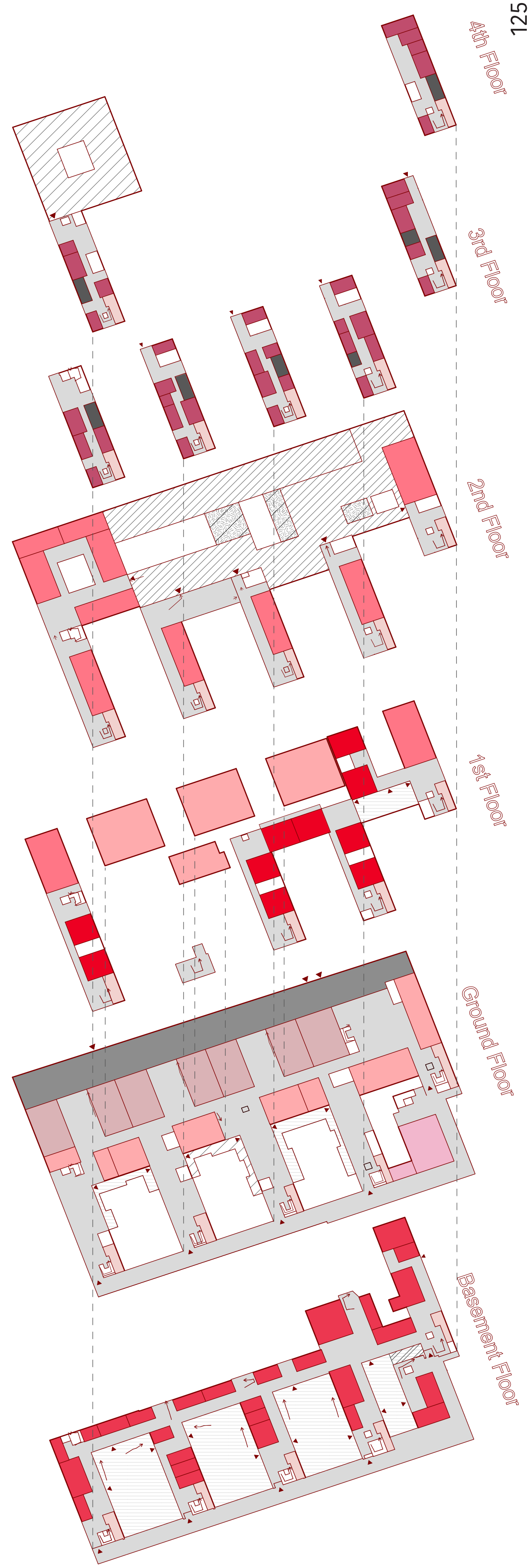
• There is no collective spaces on this part of the campus to help student engagement

• The accesibility to the outdoor spaces such as roof and courtyards is very limited and they are not effectively used.

• The connection between different floors is restricted to physical access, provided by staircases located at the ends of each wing of the building and organized along a limited set of vertical axes.

• The spaces dedicated to different disciplines are not interconnected well. The transition from one area to another is usually done through the main corridor with some acceptions.

Spatial Distribution of Design Proposal



- labs w light machinery
- labs w big machinery
- large classrooms for lectures
- cafeteria
- autonomous study spaces
- common labs / middle-size classrooms
- collaborative classrooms
- researchers' offices
- meeting rooms
- bathrooms
- outdoor collective spaces
- entrances
- interconnections

Main Design Interventions to achieve Interdisciplinary Collaboration

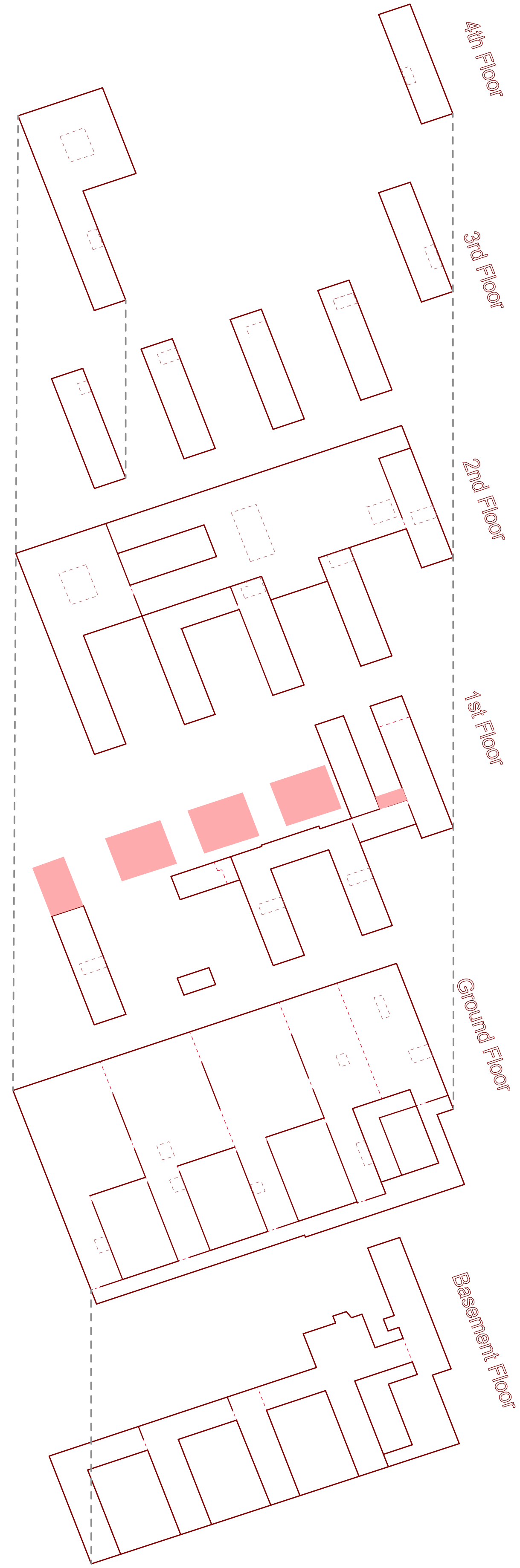
breaking down the departmental silos

The model with isolated departmental spaces of ‘intellectual silos’ is tore down **to encourage interaction and easy movement** fostering interdisciplinarity through enhanced visual and physical connectivity both horizontally and vertically

demolished boundaries

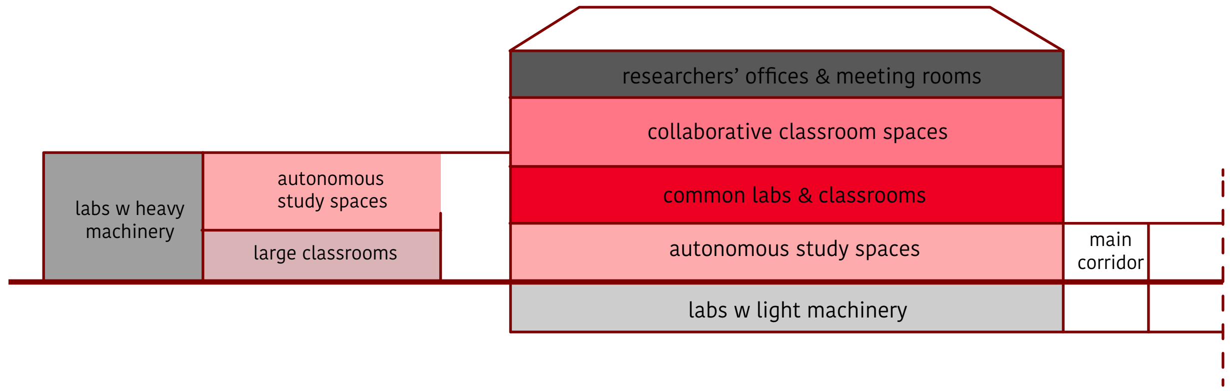
removed slab for better vertical connection

new spaces



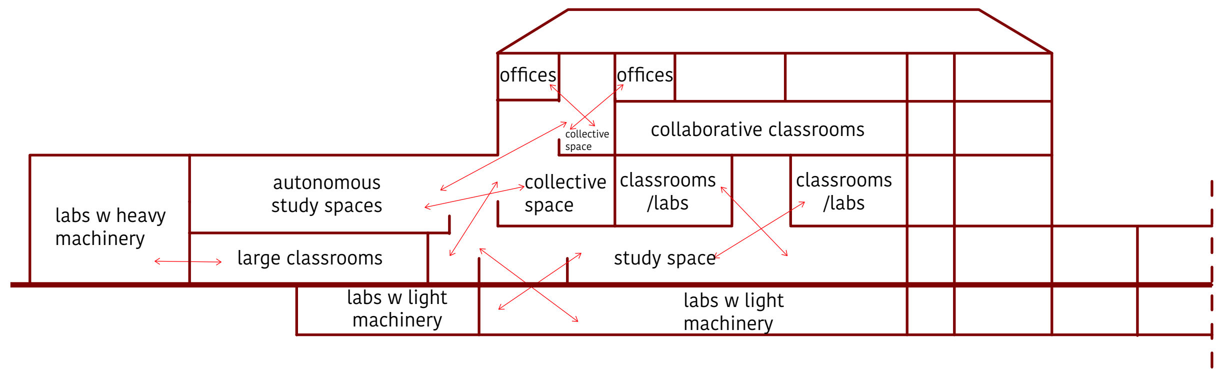
vertical organization

The ground, first, and second levels are primarily dedicated to **teaching, autonomous learning and leisure spaces for various departments** to improve the chance of **interaction** between learners, with the exception of laboratories housing heavy machinery. Meanwhile, the last floors accommodate offices for the researchers which requires more concentrated work



vertical connectivity

more natural daylight & improved visual connectivity between different floors thanks to atriums & transparent boundaries in order to foster more **interaction** between the students and researchers



integrating different disciplines' research & teaching spaces

Different types of classroom spaces and laboratories, accommodating teaching activities across various disciplines are integrated within the same building, along with spaces dedicated to research purposes in order to put different disciplines teaching and research facilities in close proximity to **enhance the interaction**

teaching & learning spaces of Politecnico di Torino departments

collaborative classrooms

large classrooms for frontal teaching

common classrooms /labs

autonomous study spaces

+

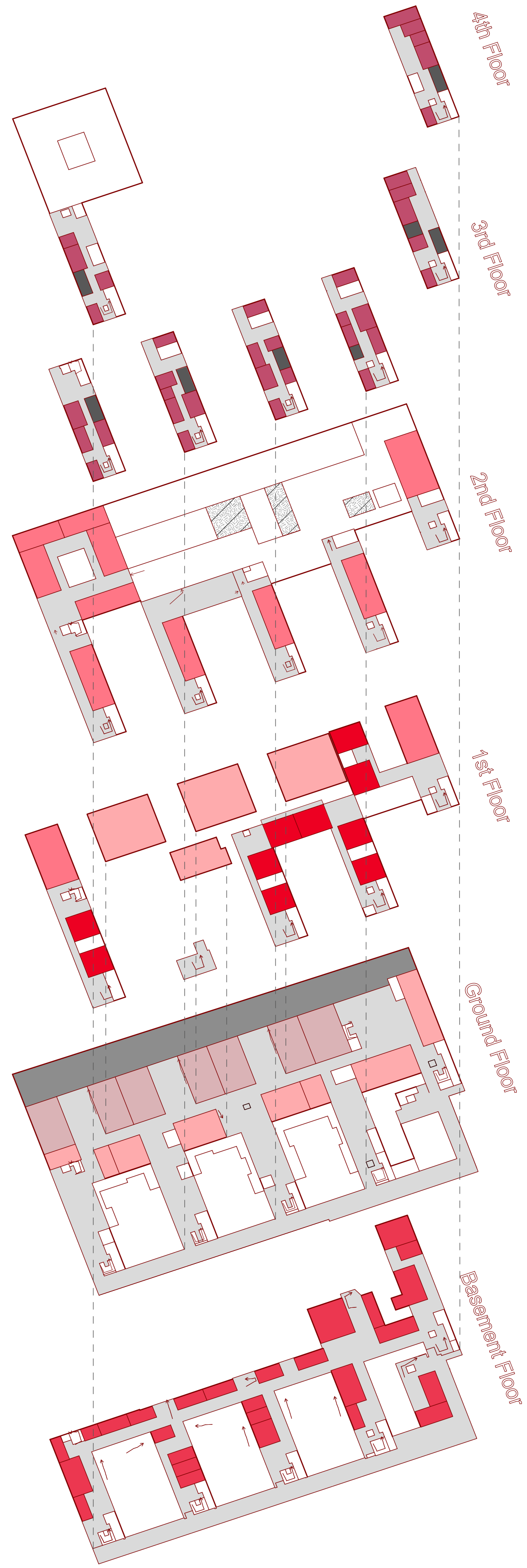
spaces for research purposes

offices

meeting rooms

labs w heavy machinery

labs w light machinery



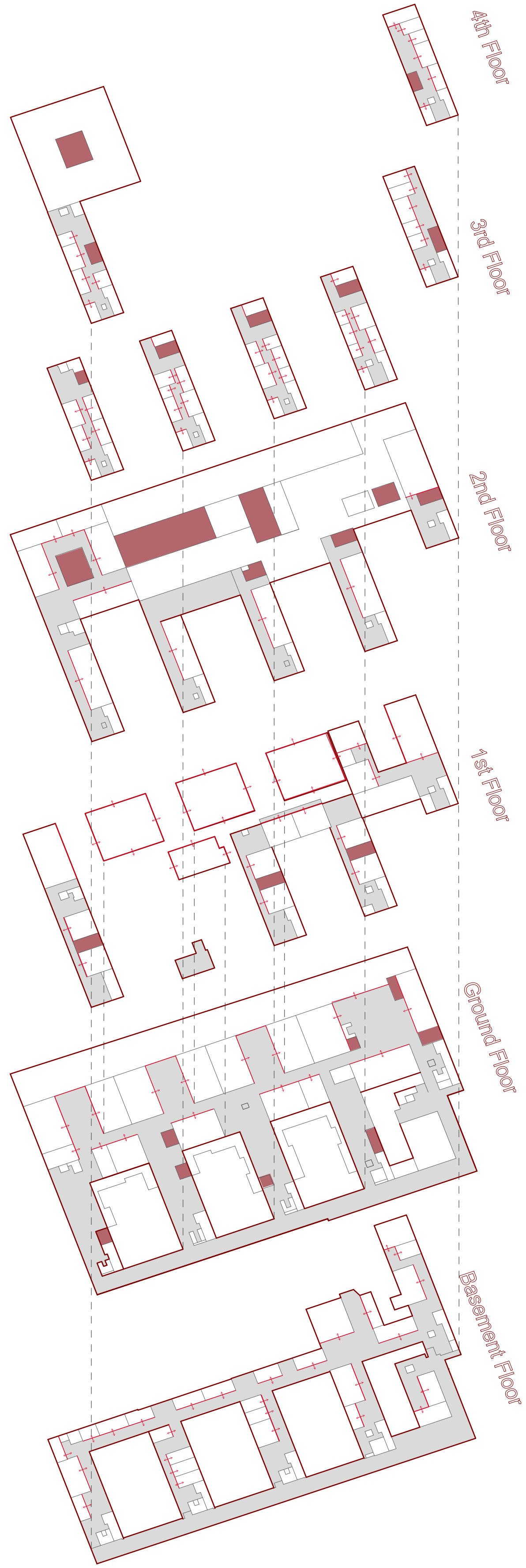
improved vertical & horizontal communications

In a higher education institute today, **interconnection and crossover** have fundamental importance. Interdisciplinary collaboration between the departments spaces is facilitated in the vertical **carving out of large open floor plates**. Students can see activities ongoing across these openings and be **encouraged to interact and meet**. Further interconnection is facilitated by **glass partitions which promote transparency and connectivity** along the internal circulation spaces.

Furthermore, horizontal spatial relationships are enhanced by breaking down some walls and having some passages between different levels.

open to below

transparent partitions

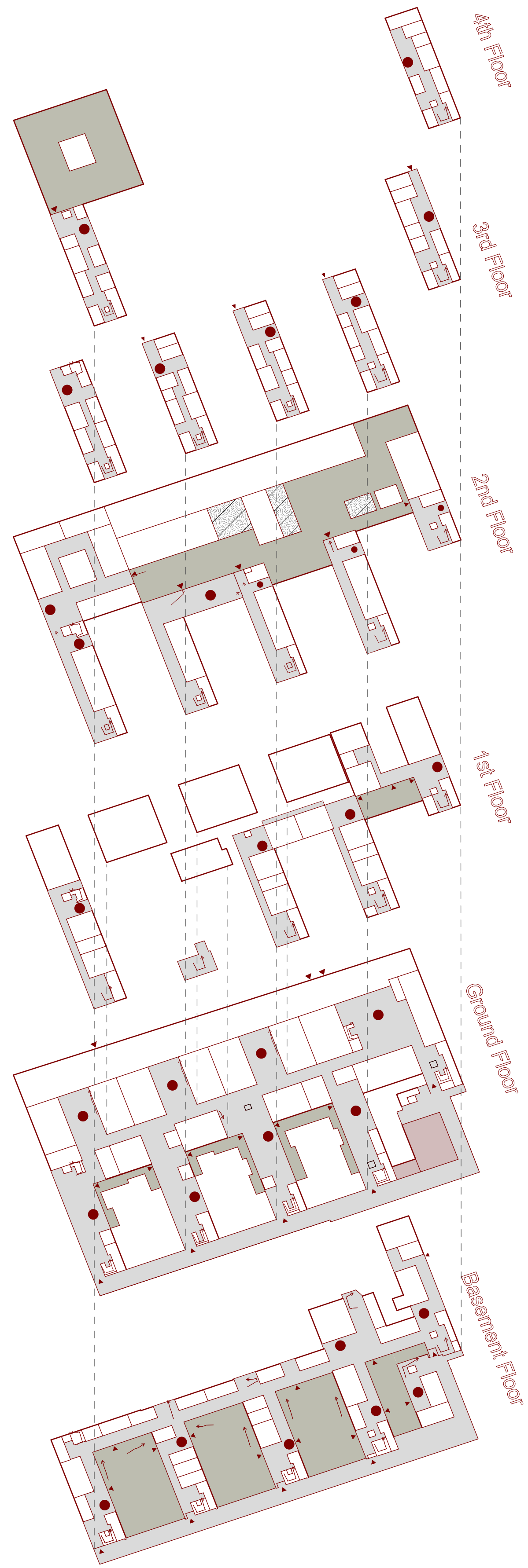


collective spaces

Interaction is enhanced through the integration of indoor & outdoor collective spaces along with open circulation elements which offer students & researchers informal meeting spaces, further encouraging interaction between the building’s six levels.

This design feature offers also a number of unidentified spaces for work and free student discussion, present throughout the development of the building in the connective and distribution spaces.

- collective spots
- outdoor areas
- cafeteria



Conclusions

Collaboration between disciplines has emerged as an essential element of higher education. Breaking down academic silos is essential to flourishing in the modern age, and universities are acknowledging this more and more. In this process, educational space can be quite important, significantly encouraging the exchange of ideas and knowledge amongst those working on various disciplines in educational environments. This thesis aims to investigate how interdisciplinary collaboration can be encouraged in technical universities through spatial design.

The second part of the thesis, the potential design features of Politecnico di Torino campuses not helping with the interdisciplinary, are explored. Built in the 1950s to host the technical university's engineering activities, the architecture of it is in favor of the departmentalization of spaces with little emphasis on fostering engagement or interaction among students working on different fields.

The case study analysis reveals how interdisciplinary work was fostered through architectural design. Three higher education buildings provided practical insights on how to encourage collaboration between diverse disciplines. The main findings from this study show that in all three of those buildings' designs, flexibility in layout, spaces designed for interaction, and a focus on user engagement stand out as recurring themes.

The project focuses on a specific portion of the Main Engineering Campus, which is currently used for research and administrative activities by some of the engineering departments. This area is composed of isolated departmental spaces, which barely offer opportunities for interaction and therefore pose a significant barrier to the interdisciplinary collaboration between researchers and students.

By integrating the design choices presented in the case studies, the project aims to address the barriers to interdisciplinarity found in existing university environments. These spatial barriers — such as isolated departments with limited interconnection, rigid circulation spaces and the lack oppurtunities for interaction — reinforce the intellectual silos. For this reason, the design favors both horizontal and vertical connectivity within the building rather than isolation and separation by using generally either no walls or transparent partitions.

Additionally, in order to facilitate a successful interdisciplinary collaboration, the design considers the changing nature of interdisciplinary collaborations by integrating different kinds of teaching, learning and research spaces which can respond to different needs.

In conclusion, the thesis emphasizes the significance of interdisciplinary collaboration within higher education institutions and analyzes the current campus design. By integrating the insights gained from the case studies, it suggests redesigning the academic space to encourage collaboration between disciplines and address the issues found at Politecnico di Torino's Main Engineering Campus. The goal of the proposed design is to create a vibrant, interconnected campus that fosters interdisciplinary collaboration, innovation, and exchange of ideas.

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