PhD in Civil and Environmental Engineering

Research title:
Safety: a project asset and opportunity for school buildings
Integration practices between distribution innovation and regulatory compliance

Funded by	Politecnico di Torino

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Context of the research activity	The building heritage of Italian schools has experienced an intense season of regulatory adjustments since the nineties. At the end of the last millennium the population growth of previous decades - which was already slowing down during the 1980s - handed down a large number of school building. They still make up almost half of the schools currently in use (MIUR 2015 data). These schools were built in a period in which pedagogical experiments and population growth were leading to results that would be discussed in subsequent years. The population decline and the evolution of the norms on fire safety and earthquake-resistant construction were the start of a new era. This period was marked by a heavy setback in the trend - accelerated after the Second World War – which was shifting the learning space from positivist models to the development of a new learning model within an educational perspective. This idea had already been implemented in Europe. In the nineties France and Germany had been testing the cognitive model for the transmission of school curricula. This led to the construction of spaces which fostered the relationship between teachers and students and introduced peer-to-peer exchange. When the new millennium began, research on school spaces gained momentum again in Italy. Nevertheless safety in schools and the consequent adaptation of existing buildings are still a problem, as

	proven by the recent building collapses at Darwin high school in Rivoli and the damages suffered by schools during the earthquakes of L'Aquila, Emilia Romagna and Amatrice. Some interesting observations can be deducted from the current situation. On one hand, the process of transforming school buildings into facilities which are fully compliant with the law has not yet stopped; luckily the existing building heritage is often at the heart of safety operations and regulatory compliance processes. On the other hand, architectural research has been focusing mainly on new buildings. The concept of educational landscape has been implemented in new schools or in building which underwent radical renovations (for instance, the case of Reggio Children, the interventions of Mario Cucinella in Emilia Romagna and the buildings in the province of Bolzano). The fundamental hypothesis of this doctoral research programme in the field of structural and civil engineering is to combine the opportunities provided by the need to ensure the safety of Italian schools with the quality of the distribution of learning spaces.

Objectives	Objective 1 **Imaging Building Diagnostics to determine the safety level of buildings and non-structural components at risk.** Non-structural components, such as false ceilings, cornices, friezes, systems, are usually neglected in structural analyses because they are wrongly considered of little importance. Unfortunately, many tragic events in recent years confirmed that these components are potentially dangerous since their collapse can easily kill people. The collapse of a false ceiling at Darwin high school in Rivoli, in which a young student (Vito Scafidi) lost his life, is an important example of this problem. Vito has become the symbol of the school building safety campaign and this scholarship should honor his memory. The lack of attention to non-structural components could be solved with educational campaigns to raise awareness especially among school teachers. Laws and regulations can also impose strict obligations in this field. However, making a reliable diagnosis of the safety level of non-structural components it is not an easy task. It is usually a matter of determining the stability of objects which are added to a pre-existing building that may have undergone various renovations and transformations over the years. Often there is neither trace of these transformations in the archives nor any technical document.

For instance, how can we determine the safety level of a heavy stone cornice in a historic building?
It is not easy to guess whether and to what extent the cornice has been clamped to the wall, if the wall has undergone any changes over time (openings, renovations, etc...), and especially if the cornice itself has got cracks which may undermine its integrity.

Traditional research methods are essentially based on visual stratigraphic tests and inspections. These methods are surely important, but they only provide a limited point of view.
For example, if we conduct a trial in a specific spot, we will only understand the condition of the object exactly where we drilled the hole. No one can tell us the condition of the object a few centimeters away.

There are many potential problems in structures as well as in structural components connected to them and they may be covered by heavy layers of plaster. And even plaster could be subject to detachments in both large and small sections, which may cause dangerous collapses for the building occupants.

Several institutions, including the Department of Civil Protection, are funding interesting projects which foster extensive surveys to provide a detailed map of the intrinsic criticalities of buildings. They are large-scale surveys, carried out using massive human resources and traditional survey techniques. In general, such extensive tasks do not require highly specialized technical skills, but many man-months.

The goal of this project is instead to research an unexplored field. It aims to define new research protocols with highly innovative techniques and technologies including:

- Three-dimensional laser scanning modeling;

- Luminescent mechanical survey;

- Ground-penetrating radar survey;

- Thermography;

- X-ray and gamma radiography

- Interferometric techniques (speckle and al.);

- Neutron radiography;

- Geophysical seismic survey;

- Geoelectric survey;

- Three-dimensional electrical resistance tomography;

- Geomagnetic survey.

This kind of surveys has been applied for years in the biomedical field. More recently it has been successfully introduced for building diagnostics, especially for historical buildings.

Just as a physician can rely on sophisticated tools - such as Computed Tomography (CT scan) - to determine the condition of a patient condition, so an engineer should have access to similar analysis tools. This way the engineer would be able to see through the plaster and detect possible trauma and pathologies of a building, especially those related to non-structural components.

In many U.S. engineering universities there are specific degree programmes which train future engineers in "Imaging Building Diagnostics ". New computing capabilities and big data techniques may further drive this process in this direction.

It is impossible to bridge this gap by simply setting up a single scholarship. Moreover Italy lacks specific equipment which could be suitable for this type of research and substantial investments would be necessary to purchase it.

However, we believe that the PhD candidate can play a fundamental role in researching the state of the art in this type of analysis. The PhD candidate could spend long periods of stay at foreign institutions, where these techniques have been used for years.

The results of this research should foster future investments by Italian institutions.

Objective 2) Reading of technical regulations from a performative perspective

The objective is to identify the potential that standards and norms may offer in terms of the distribution of spaces, especially in new buildings, but also in existing ones.

Implementing an educational perspective within existing buildings is often hindered by the need to install fire barriers, reinforced concrete structures and emergency exits.

This research aims to study these architectural elements as possible components of the educational landscape itself. They may be capable not only of making schools safe, but also they could be intended as tools for child safety education.

The result is the transformation of technical data (i.e. norms) into project data, as an opportunity for the school-community stakeholders to raise their voice.

	The process of adjusting to the standards can be regarded as a project fact and as an opportunity for the creation of an educational landscape. From this point of view impacting on the school transformation process (even a partial transformation) will become a fact of the project itself. This is going to advance economies of scale: a single construction site (needed for regulatory adjustments) is going to bring about changes in the distribution with an educational connotation. The integration of the educational concept with technical norms seems to be a still unexplored research topic: nowadays research on safety has led to advanced results, particularly in the anti-seismic field. Several national agencies, including INDIRE as the leading stakeholder, have been dealing with the innovation of educational spaces. Nevertheless the implementation of these two aspects in a joint and multidisciplinary research project has not been widely studied yet both at national and international level. The expected outcomes in the exploration of this open field are: - The drafting of "high level" guidelines for interventions on the existing building heritage (depending on the type of building) for architects, engineers and designers in general, technical offices and municipalities. - A Living Lab in a limited number of schools where a regulatory compliance process is already underway. The case studies will be identified during the research project and will serve as a pilot project to test the guidelines on which the interventions will be based. All the stakeholders of the school community will be involved in the Living Lab design process. The objective is to define both the final result and the process needed for its achievement. - In the long term, and beyond the timeline for the conclusion of this research project, a partial revision of technical standards with an eye to make their application more permeable to space innovation in schools.

Skills and competencies for the development of the activity	The skills required include: building engineering, structural engineering and mechanics, knowledge of the main safety and security issues in public buildings.