

# Responsive Architecture: New paradigms of urban relations

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**Abstract.** The relationship between architecture and technology throughout history has continually meant the discipline's adaptation to new technological advances. Simultaneously, the contemporary city allows us to see the processes of evolution or involution in those who think about it, design it, build it and live it. In recent years, new technologies have been introduced that allow the morphological flexibility of buildings, such as responsive architecture, where the shape of the building can be reprogrammed and adapted to its spatial environment. These technologies function as a programmed response mechanism from catalytic elements thrown by the environment, these catalysts can vary from sensory elements to bio-climatic elements. This paper seeks to reflect on a new turn of these new adaptable technologies, where the human being himself is the key catalyst in the responsive process of these new buildings. This strives to promote a methodology where, through the union of the user participation and responsive environments, it is possible to introduce a new concept of Participatory Design. In this way, a new possibility can be introduced to create buildings that are constantly at the forefront of the social needs of the communities, where users not only manage to be part of the construction and design of the building but are also part of its constant evolutionary process.

## 1 Towards a new typology

Throughout history, society has found itself in a constant state of evolution, where needs and priorities are transformed according to the constant introduction of technological innovations. Likewise, the discipline of architecture has been able to adapt to these changes thanks to the incorporation of new technologies in buildings. The purpose is to be able to supply the demand that is not only constant, but also changing. This process of continuous transformation can be seen in contemporary cities from the eyes of not only those who design and organize it, but also those who live in it.

Anthony Vidler in his text "The third typology" tells us about the need for an architectural typology which does not function as an isolated entity alienated from its context, but rather a typology that is defined by the relationship of the building with its environment.

Vidler manages to conclude this from the analysis of the transformation that the architectural typology has undergone throughout history. This is defined by a three-phase classification. The first refers to the origins of the discipline where its function was governed by the harmony of the architectural element with nature. This changed after the industrial revolution where a second typology arises, which is assimilated to the world of machine production, where the essence of these buildings resides in the world of engines. Finally Vidler emphasizes the need to change towards a new typology, in which his point of concern is the city. This new

typology is based on reason, classification and the meaning of public architecture.

"The architectural object cannot be considered as a single and isolated event because it is delimited by the world that surrounds it" (Vidler, 1977)

Nowadays, a building cannot be conceived as a single element, but as a component that is part of a large system (the city), therefore if urban systems are constantly transformed, it is necessary to introduce flexible buildings that have the ability to adapt to this constant change.

## 2 The human aspect in the process of Responsive Architecture

Thanks to new technological advances, the concept of the flexibility of a building has become possible, as is the concept of "Responsive Architecture".

Responsive Architecture is one that measures the current conditions of the environment allowing buildings to adapt their shape, appearance, color or nature in a receptive or sensitive way. This architecture integrates technological and environmental possibilities to seek solutions based on its flexibility and reconfiguration.

The concept of "Responsiveness" works from the reaction of the building to catalytic elements. These catalysts are the information that the building receives

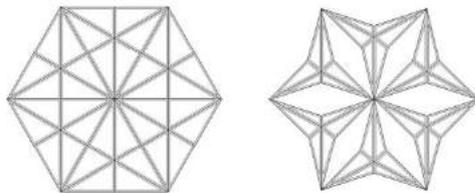
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from the external context and from this the building transforms as a response mechanism.

Catalysts can vary from sensory elements such as the emission of noise or the accentuation of certain exterior views, to bioclimatic elements such as solar incidence, natural light or winds.

An example of this concept are the Al-Bahr Towers by Aedas Architects, these towers are located in Abu Dhabi and have a responsive technology that works through a sensitive skin, this skin works as a façade shading system where its openings react to solar incidence, thereby generating comfort inside the building and great energy savings.



**Fig. 1.** Scheme of the movable modules fastened to the façade; closed element (on the left) and open (on the right)

The identity of the city is not only defined by its spatial conditions and its climate, but by the users who inhabit it. Therefore, when the intention of the new architectural typology is to adapt to its urban context, it is necessary to reflect on the role of the human in the role of responsive architecture and thus consider the possibility of introducing the citizen as the main catalyst element that defines the transformation of buildings.

### 3 A new approach of Participatory Design

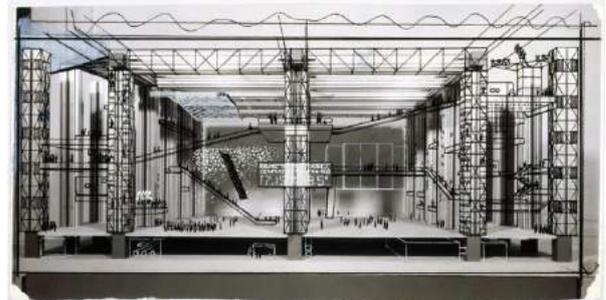
Introducing the human as a catalyst in the responsive process of a building generates a new modality of participatory design where the community is not only part of the initial design and construction process of the project but also in its future.

According to Sanoff (2000), participatory design is the attitude towards creating and managing spaces for people. This is based on the principle that the building and its surroundings work best if citizens are active and involved in the creation and management of these spaces instead of just being treated as a passive consumer.

Participatory design is not a new term, but over the years it has managed to evolve thanks to new technological advances that have served as tools to facilitate the relationship between citizens and the architectural project, with new technologies it is possible to carry This relationship a step forward, where the user-building relationship instead of being ephemeral once the project is finished, it can be constant and lasting, because the building would be open to its transformation by proposing an infinity of possible future scenarios.

### 4 Once utopic, now a reality

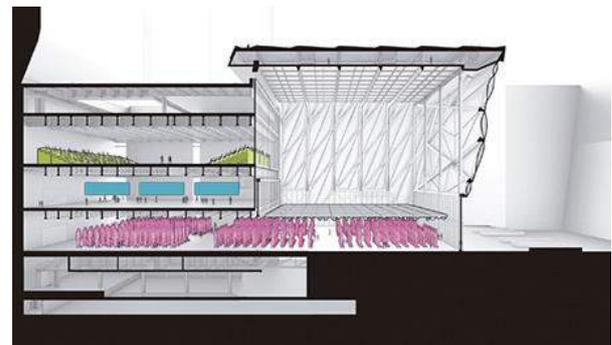
This possibility could previously seem utopian, as shown in the project “Fun Palace” (1961) by the visionary Cedric Price. Where he proposed a reconfigurable structure as a project that could give the possibility of transforming itself in order to supply the need for leisure activities of all the inhabitants in the present and future.



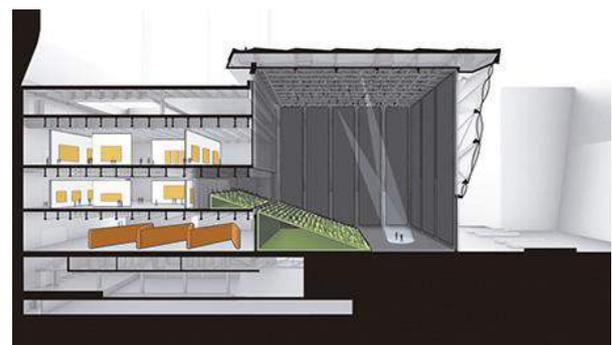
**Fig. 2.** Perspective Drawing of Price conceptual project

What in 1961 might seem impossible with Price's proposal, today thanks to new technologies it can be achieved. A good example of this is the project "The Shed" by Diller Scofidio + Renfro in New York, this building serves as a centre for artistic and cultural events which, due to its kinetic system and new materials, enhances the possibility that the building can reconfigure its shape and interiors to cater for a large number of possible programmatic scenarios.

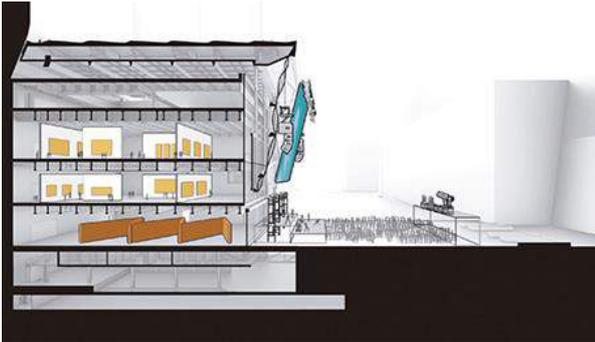
Likewise, the Shed is a clear example of the introduction of new materials to enhance the flexibility of the building, one of these materials is ETFE, which is a thermoplastic fluoropolymer, this material has great resistance and at the same time great lightness, which gives the possibility of allowing the movement and flexibility of the building's cover.



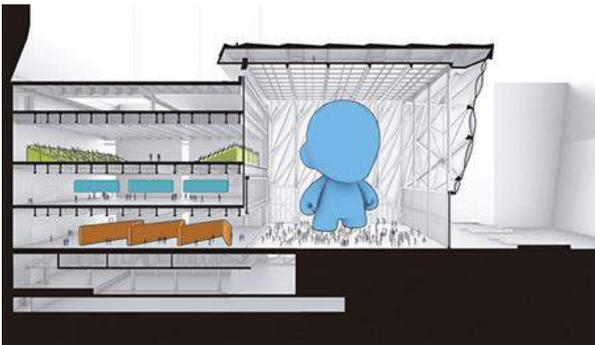
**Fig. 3.** Perspective section of the programmatic possibilities of the Shed, scenario 1.



**Fig. 4.** Perspective section of the programmatic possibilities of the Shed, scenario 2.



**Fig. 5.** Perspective section of the programmatic possibilities of the Shed, scenario 3.



**Fig. 6** Perspective section of the programmatic possibilities of the Shed, scenario 4.

## 5 A responsive architectural agenda in Latin America

Just as the architectural discipline evolves according to new technological advances, the practices that involve the user must evolve, because the person must always be the centre of the design, taking into account that they will be the ones who will eventually inhabit the building. The evolution of the machine is not equivalent to the alienation of the human within the design process of cities and their buildings, on the contrary it must be introduced as new alternatives for the involvement and participation of citizens in their urban context.

Once understanding the potential of responsive architecture as a tool for citizen involvement in their urban context, we seek to reflect on how these new technologies can contribute to the design and transformation of public space in Latin American cities.

In the Latin American city there is a problem where many public spaces have been designed by political commitment and not with the intention of promoting urban life, this is reflected in spaces such as community centres and parks that were designed without the involvement of users, these spaces have become obsolete due to failing to supply the current needs of the community.

When it comes to the design of public space, it is essential to put the user first, since they are the main element that gives life and identity to the building and therefore to the city.

It is necessary to question, in what way can Latin American cities propose a responsive architecture agenda to improve the level of quality of urban life?

The new adaptable technologies give the possibility of involving the citizen in the present and future of their public space, by involving these new technologies in the Latin American public space it is possible to ensure the relevance of these spaces within the changing urban context. This can be achieved from a participatory design methodology where the involvement is constant, this can be achieved by social methods such as workshops and surveys that can establish a collective thought which serves as the main catalyst that defines the present and future of these spaces.

This reflection shows us how new technological innovations can be used as tools for the social problems in the urban context, by applying this gives the possibility of humanizing new technologies where instead of alienating the citizen in the face of new changes, it is possible to involve them in this process of evolution and development of their metropolis.

## 6 Towards a new educational model

In order to move towards this new future of urban connection through technology, it is also necessary to educate the new generations about the implementation of this practice.

Young designers will be one of the main actors that will define the city of tomorrow, for which reason it is important to introduce this concept early in their educational development with the intention that it can be implemented in the city of the future.

To prove this, during this research a new educational methodology was implemented, which encourages architecture students to not only design for the present but also to prepare for future needs.

This educational methodology was carried out at the School of Architecture of the University of Monterrey (UDEM) in the Integral Design I workshop, taught by Ana Cristina García-Luna Romero

Workshop members: Ángela G., Jesús S., Jorge A., Pedro A., Pamela G., Fernanda C., Maria C., Rosa R., Maria Jose C., Saul M., Alexa S.

Every semester in the design workshops a specific typology is defined that all groups must elaborate, this typology is defined by the entire campus faculty, but this year the Integral Design I workshop, Luna decided to include additional requirements from the one the faculty defines, this with the intention of pushing her students to carry out not only a good project but one that is also socially responsive.

In the Fall semester 2021, a semi-professional baseball stadium was selected as the common architectural typology for the workshop.

As an exercise to encourage the morphological flexibility of the building and thus its possible adaptability to its context, the following requirements were taken into consideration in the development of the project:

Requisite 1: The residual spaces of the project, at first can be implemented as parking space, however, these areas must be designed in such a way that the structure of the building can later use them for its

morphological adaptability, so that it can be modified or ease the addition of new strategies and programmatic possibilities.

Requisite 2: The building must include a mixed system, in which an architectural skin is implemented, which can function as a sustainable proposal. This skin proposal must react in relation to the climatic criteria of the site, with the purpose of promoting energy savings and spatial comfort.

Requisite 3: The program of the typology must be rethought by each team, with the intention of including different possible alternate uses, thereby creating a diverse program which can enhance the use and life cycle of the building. To reach this, a field study must be previously prepared, in which, based on the findings collected by the site analysis and existing users, selected programmatic possibilities can be defined and argued.

Requisite 4: The proposal of each project must, in addition to being based on urban regulations, site analysis and design guidelines, comply with the objective number 3 (Health and Well-being) of the United Nations sustainable development goals. This objective is responsible for promoting well-being and ensuring a healthy lifestyle for all ages. Based on this, the project must ensure the promotion of physical activities that can promote a more active lifestyle for all the inhabitants of the community. Therefore, a diverse program must be encouraged that is able to attract all types of users from the current and future communities, by this, it is possible to ensure its programmatic relevance and therefore constantly benefit the community's lifestyle.

Requisite 5: Last but not least, it is always necessary to keep in mind that the design is for the people. Therefore it must be 100% accessible by anyone of any age and physical condition.

Based on these requirements for the workshop project, a socially responsive proposal is encouraged through these three elements: the use of the residual space, the implementation of an architectural skin, and the pursuit of programmatic diversity. By achieving this, it is possible to ensure that the architectural project will not only be able to meet the current needs of the community, but also adapt to its future needs.

One of the most interesting aspects of this exercise is that the workshop will be separated into teams, which gives a chance on observing different ways on how each team can solve the same spatial problem, demonstrating how there can be more than one alternative to meet these urban context necessities.

## 6.1 The residual space

The first element to consider in the elaboration of an adaptable project is the residual space, since this can be considered as a possible extension of the building's spatial limit. The more residual space is available, the possibility of expansion and transformation increases.

Therefore, it is necessary from the beginning to define the design and purpose of this void, not as a definitive proposal, but as a canvas that can allow or facilitate the evolution of the building in the future.

There are two fundamental elements to consider in the design of the residual space, its morphology and location, because these criteria can determine the future for that space.

This can be observed through the project's master plans of the Integral Design I workshop teams, where each residual strategy generated a different scenario for the building's future.

This contrast can be observed in the management of residual space between Angela and David's team project, and Rosa and Maria's team project.

In the first project, Angela and David opted for an agglomeration of all the residual space, locating it on the northern periphery of the land, being located between the main avenue and the baseball stadium, in this scenario the residual space can serve as a buffer, distancing the activities of the stadium from the noise pollution of the avenue, likewise, due to its large scale it provides a greater possibility of expansion for the building in the future.

In the second project, Rosa and Maria defined their implementation of the residual space in a more dispersed approach and placing these spaces in the central space of the venue, this approach was implemented with the intention that these spaces will not only function as parking for the stadium but also for the other activities that are also held on the premises. By implementing this strategy, it enables the possibility for the residual space to not only serve as the future enhancement of the stadium, as it also opens the possibility to be used by the other site activities, giving the possibility that in the future the expansion and transformation will not only occur in the main building but also in adjacent buildings.

Through this, it can be shown how the residual space not only serves as a complement of the existing buildings but can also define the future of the project.

## 6.2 The architectural skin

The architectural skin is another significant element to consider when it comes to the building's adaptability. Either through its system or materials, the skin should act as a response mechanism to the environmental catalysts, either sensory, such as visual permeability or noise pollution, or climatic, such as rain, sunlight, winds, or the management of natural light.

To achieve this, it was demanded as a requirement that each of the teams involved the element of the architectural skin in their projects, this could be accomplished through the implementation of material innovations or new parametric systems and mechanisms.

Each team started from a climatic analysis of the site, in which, based on the findings, the environmental needs that the skin system should cover were defined.

These analyses included a study of relevant views showing the ones the project should emphasize, a study of prevailing winds that the project should take advantage of, and a study of sunlight that the project should consider to obtain spatial comfort.

Even so, the findings of the analysis were similar for each team, due to the fact that all the projects were located on the same land, the way in which each team

solved the environmental needs was diverse, thus generating different skin scenarios where each one varies in materiality and morphology.

Angela and David's team opted for a system based on irregular triangular geometric shapes (fig.7). This triangulation system had a proposal of perforations which were located in the collision zone of the prevailing winds, this with the intention that the perforations can control these currents and then use them to keep the spectators' seats cool. The materiality of this skin was combination between an I-tension textile fiber and a natural lichen (*Stellaris Cladonia*), the lichen when subjected to an ecological process replaced the sap with glycerine compounds which can ensure the appearance and conservation of the skin. for a long period of time.



**Fig. 7** Exterior perspective of the architectural skin of the project by Angela G. and Jesús David S.

Jorge and Pedro's team introduced a kinetic skin system in their project (fig.8), Helio Trace, which can track the path of the sun and react to its solar incidence. This skin works through a system of kinetic curtains anchored to the building's exterior, these curtains are operated by computer-driven wind models, this computer system takes into account the seasonal climates and the properties of the daily solar trajectories. Their system of kinetic curtains works through 3 layers, the first one is composed by fins, that can be folded vertically or horizontally, which can cover any possibility of solar rotation, the second layer is made by a system of micro-perforated sheets that can allow and control the passage of natural light into the building, and finally the third layer is composed by polarized glass which prevents any excess of unwanted sunlight from entering the spaces. From this kinetic system, Jorge and Pedro managed to introduce a proposal that manages to constantly adapt to the building's environmental needs.



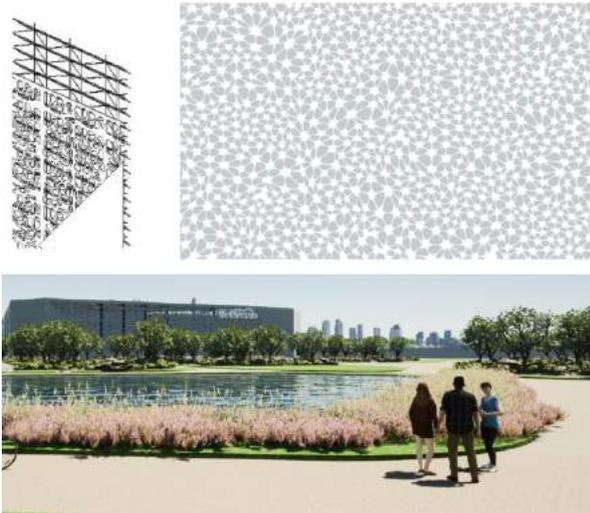
**Fig. 8** Exterior perspective of the kinetic skin of the project by Jorge A. and Pedro A.

In their architectural skin proposal (fig.9), Rosa and Maria's team selected a system of air bubbles formed by ETFE (Ethylene-Tetra-Fluoro-Ethylene). The transparency of this material can be very versatile, which can be modified depending on the space's needs, like natural light and thermal insulation. Their skin system has an integrated photovoltaic solar energy system (BIPV- Building Integrated Photovoltaics) composed of organic cells printed on the skin's membranes, which through their reaction to solar incidence are able to generate electrical energy which can later be used for the installations of the stadium. Thus generating a system which not only protects the building from solar incidence, but also uses it as a source of clean energy.



**Fig. 9** Exterior perspective of the skin of the project by María C. and Rosa R.

For their project Alexandra, Saul and Maria Jose opted for a proposal that uses the innovative material Prosolve 370e, which acts as a decontaminating material that counteracts the contamination of the site's air, this is can be possible thanks to its chemical process generated from the reaction of the modules with sunlight. This system works through modules that are coated with a paint that contains titanium dioxide, this pigment is used for protection from ultraviolet rays. Once the ultraviolet rays reach the modules, this carbon dioxide reacts, generating a chemical process that helps reduce polluting gases found in the air, such as nitrogen monoxide. Another advantage of the Prosolve system is that the screen of the modules can manage to filter the direct sunlight, and thanks to its double layer, it reduces the temperature inside the building. Due to its morphology, each module has the ability to efficiently receive and disperse the sun's rays, ensuring that more surface area is able to absorb the air's pollution, since the more sunlight is reflected on the material, the more pollution will be reduced. Alexa, Saul and Maria Jose managed to implement this system in a strategic way (fig.10), in which, based on the bioclimatic study of the site, they managed to place the system modules in the facades of the building that receive the highest solar incidence. The skin system used in this project shows how the introduction of new materials can not only help the efficiency and operation of the building, but also its surrounding context, thus improving the quality of life of the citizens.



**Fig. 10** Prosolve architectural skin from the project by María Jose C., Saul M. and Alexa S.

From the results obtained by each of the team's proposals, it was possible to observe the different alternatives that can be applied to solving a spatial problem through the implementation of an architectural skin. Some students were inclined to a solution based on an innovative system, such as the management of the skin's perforations for the control and use of winds or the use of a kinetic system that is able to react from the solar incidence and the rotation of the sun. While other students sought to implement solutions based on the implementation of new materials, such as the use of ETFE with a photovoltaic energy system or the implementation of the Prosolve 370e material as a decontamination solution. Thus demonstrating how by introducing an educational methodology that encourages students to innovate through research and the introduction of new systems and materials, it enables the possibility of creating innovative solutions that can become new proposals for the future.

### 6.3 Programmatic diversity

Finally, the element that was taken into account to ensure the relevance of the architectural typology in its urban context was the definition of the programmatic additions, seeking that the project will not only react to the spatial demand foreseen by the prerequisites of the projects typology but also to the needs from its adjacent context. This was carried out through an implementation of a diverse programmatic proposal, where it enables the possibility of adding new uses that could encourage urban life in the city.

In order to achieve the definition of this program, each team carried out a field study, where through the analysis of the users, adjacent residences, land use and economic activities, it was possible to define a program that assertively meets the needs of the community.

Likewise, a constant relevance of this program should be considered, for which it was also demanded that the teams should take into consideration that these spaces may have the possibility of adapting to other uses

in the future, either through their internal configuration or their expansion by using their residual spaces.

All of the teams were able to define different programmatic proposals, each one defined from the site analysis, thereby demonstrating a versatility of programmatic solutions, proving that there are different strategies to ensure the relevance of a building in its urban context.

Angela and David's team decided to incorporate a student centre to their architectural project (fig. 11), which was defined based on the findings of their user analysis, where it was found that the majority of the population in the nearby context were infants and young adults. Likewise, Angela and David defined that their educational centre should be flexible, where the classes and courses taught could be adapted according to the needs of the community, where the community can also define the courses based on what they are interested in learning, thereby promoting that this project can not only encourages physical exercise but also educational activities, and thereby helping the existing community in different ways.



**Fig. 11** Interior perspective of the project by Angela G. and Jesús David S.

Pamela and Fernanda's team decided to opt for a path in which the additional program could promote cultural activities in the area, due from the analysis of land use were they found a lack of this program in the nearby urban context, Pamela and Fernanda implemented a solution to this problem by including an auditorium within the project, which could serve as the venue for cultural events, from concerts to children's recitals, thereby promoting new possibilities to strengthen social connections and urban life.

Rosa and Maria's team sought through their program to rebuild the social fabric of the context, this achieved through the implementation of recreational spaces that manage to involve the nearby community and also generate safe meeting points. They accomplished this through a diverse recreational program that gives the possibility of attracting various types of users to the same space and thus unifying the community. The team decided to involve a diverse range of sports and leisure activities, with the intention of inviting other users who are not completely interested in the main concept, this being baseball, achieving this through the implementation of soccer, football, basketball, tennis, a skatepark, among others activities. Likewise, based on the analysis of the economic activities in the area, the team chose to include commercial spaces (fig. 12) that could boost or enhance the community's economy and,

in the same way, promote local businesses. By this, the program not only supports the community through the implementation of social activities but also can contribute to the economic stability of the inhabitants.



**Fig. 12** Interior commercial area of the project of María C. and Rosa R.

Taking into account all the different programmatic strategies shown by the proposals of the design workshop teams, it is possible to conclude that there are various methods to intervene in a social problem based on a building's program. The objective is that each of these solutions can arise from an analysis of what already exists. With this, the proposal is achieved as a reaction to the current problems, thus demonstrating the evolution of the discipline which is now inclined towards a new architectural typology that does not arise by itself but from its connection with the existing city and its needs.

## 6.4 A socially responsive proposal

As we saw in the previous sections, there are different ways to ensure architectural responsiveness, either through its residual space, its skin or its program.

For an architectural project to achieve a greater possibility of adapting to change, it is necessary to consider these 3 elements, since for a building to have the possibility of adapting it should not be spatially limited, it must consider its climatic context and have ways of reacting to it, likewise, it must consider its existing context and subsequently its program should emerge as a response to it.

By implementing this educational methodology, students are encouraged to lean towards the creation of this new typology, which functions not as an isolated entity but as one that can react and adapt to the city and its inhabitants.

## 7 Conclusion

All this work of analysis and practice invites us to reflect on the new direction of architecture and the city, where through the implementation of new technologies it is possible to approach a typology that is in constant connection with its urban context and inhabitants. An architecture in which citizens regain a leading role in the city's design, based on tools that facilitate the constant adaptation of buildings to the demand of a changing society, where this new typology does not disrupt its

context, on the contrary, that it becomes an integral component of the urban system.

The only way in which we can achieve urban life is by putting the people first, we must use this new technology to the advantage of the urban society, where it manages to strengthen the connection between the city and its inhabitants.

The idea of this project is to rethink what role technology should play in the city of the future. Should it be considered only as an element that promotes change? Or as the bridge that will strengthen urban life?

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## Figures

1. Scheme of the movable modules fastened to the façade, Author: Berbesz, A. M.
2. Perspective Drawing of Price conceptual project, Author: Price, C.
3. Perspective Section, Scenario 1, Author: Diller Scofidio + Renfro
4. Perspective Section, Scenario 2, Author: Diller Scofidio + Renfro
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