

## Adaptive Reuse Architecture Documentation and Analysis

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### Abstract

Buildings have been reused throughout history. The current discourse of diverse trends in preservation together with awareness for sustainable environments has led to a surge in adaptive reuse projects. The combination of new and old architecture ensures the retaining of authentic character while providing an appropriate new use and revitalizing the structure. Learning from precedents is one of the most important knowledge bases for architects. It has many layers of knowledge referring to the old building and its original use, the transformed building and its new use, and the transformation itself. The objective of this work is to propose a theoretical and practical background for a systematic process to support adaptive reuse architecture precedent E-learning. A procedure for the analysis has been developed to fit the specific nature of this architecture data. This paper is presenting the analysis principles and demonstrates the system as a powerful infrastructure for E-learning.

**Keywords:** Adaptive reuse of Buildings; Formal analysis; Learning from precedents; Creative design; Design process

### Introduction

Adaptive reuse is a special form of refurbishment that poses quite difficult challenges for designers. Changing the functional classification of a building introduces new regulatory conditions and may require rezoning approval. Nevertheless, there are clear economic, environmental and social benefits that can make this option attractive to developers. Adaptive reuse has been successfully applied on many types of facilities around the world. It is seen as being fundamental to sound government policy and sustainable development in the US, Canada, Hong Kong, North Africa, and Australia [1]. Although buildings have been reused throughout history, new architectural interventions are seen as a creative way to breathe new life into an existing historic context, while reinventing an economic and social value. Combining new and old architecture ensures the retaining of authentic character while providing an appropriate new use. Such new use eventually adds to the building's historic fabric and to the built fabric as a whole (MacDonald, 2009).

The provocative "Cronocoas" exhibition by Rem Koolhaas in New York emphasized the problematic agenda of building preservation. Has preservation become a dangerous epidemic? Is it destroying our cities? Koolhaas draws on ideas that have been circulating in architectural circles for several years now; specifically the argument presented by many academics that preservation movements worldwide, working hand in hand with governments and developers, have become a force for gentrification and social displacement, driving out the poor to make room for wealthy homeowners and tourists. This, Koolhaas argues, will bring about "a new form of historical amnesia, one that, perversely, only further alienates us from the past" [2]. It is estimated that some 70% of structures existing today will still be in existence 50 years from now, and so refurbishment and updating for current and future needs must become central in our current practices. Thus, the correct way to deal with historical structures may well be the adaptive reuse strategy.

The design process of such adaptive reused architecture is very different than conventional design processes, and may require other or additional skills. Referring to their work at the Tate Modern museum in London, world-acclaimed architects Jacques Herzog and Pierre de Meuron said that "the attendant constraints demanded a very different kind of creative energy" [3]. They added that their strategy was to accept the physical power of Bankside's massive mountain-like brick building

and to enhance it rather than break it or try to diminish it. Such structures must be studied carefully for their physical and metaphysical qualities and designers must consider all aspects and decide on tactics and strategies for their actions.

When designing a new building, the architect, either consciously or not, uses an architectural strategy that will inform the order of the building. These strategic moves are of course supplemented by a complex combination of various factors such as site conditions, structural systems, programmatic requirements, and his or her own personal vision [4]. Brooker and Stone argue that when a building is reused, the most important and meaningful factor in the design is the original building and the relationship between the old and the new. Langston et al. propose a model that assists in transforming the property stakeholders' traditional decision-making processes to more sustainable practices, strategies, and outcomes by providing a means by which industry can identify and rank existing buildings that have high potential for adaptive reuse. The model explores the relationship between financial, environmental, and social parameters associated with the adaptive reuse of buildings. This point of view is critical for the decision-makers' level.

In this paper we focus on the design strategies and knowledge-based design and on the role of precedent study and analysis in adaptive reused architecture. The objective of this work is to propose a theoretical and practical background for a systematic process to support adaptive reuse architecture precedent E-learning. For this purpose, several case studies were analyzed using a structured analysis process.

Section 2 introduces the background information for the current work and Section 3 discusses the procedure for the proposed analysis of adaptive reuse precedents and demonstrates the full analysis process as applied to one of the case studies. Section 4 presents the classification

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process of sixteen case studies based on the variant analysis, and Section 5 suggests an intelligent search based on related concepts. Section 6 concludes the discussion of the proposed analysis and its role in the design process, and suggests future directions for development and use.

## Background

### Knowledge-based architecture design

One of the basic assumptions of this work is that knowledge-based architecture design relies on understanding design precedents and that the design process is a dynamic process of adaptation and transformation of knowledge and early attempts or experiences to correspond with current needs [5,6]. Therefore, the broader the horizons of knowledge used for the design, the richer and more accurate the design and the design process. This work focuses on the formal knowledge, structural knowledge, materiality, strategies and tactics of adaptive reuse architecture.

Architecture's basic elements, such as form and space, have been present throughout human history and so it is most important to examine continuity, to understand similarities and differences and the variant patterns. Clark (1985) refers to the continuity as transforming the past and becoming part of the present. Ching (1979) argues that form and space may be considered to be the architect's vocabulary, and that architecture is expressed through this medium of forms. The history of architecture theory since Vitruvius (80 BC) is characterized by a search for universal concepts that can be evaluated regardless of their place in history. The approach to the quest for a logic system has always been abstract approach (Von Meiss, 1990). Formal analysis is the basic for identifying formal and spatial attributes, and since it is executed in greater detail, it is expected to reveal deeper layers of architectural knowledge. Formal analysis is a controlled abstraction process, which means that the search for the essence principals of architectural knowledge is not usually directly visible. Abstraction may lead to an exploration of formal connections among variant architecture precedents that otherwise would not be related. It is important to note that abstract processes do not necessarily follow the design process, rather they are carried out from an objective point of view [6-8].

Abstract formal analysis is commonly used for architecture precedent classification. Various intensive attempts at such analysis were presented in master works by Ching (1979), Clark and Pause (1985) and Baker (1985), among others. Methods introduced by Ching (1979) and Clark and Pause (1985) served as part of the tools used to develop the method presented here.

### Teaching adaptive reuse architecture studio and theory

Recycling and reusing existing building is an important task for architects. It demands considerable attention in architecture schools as it demands different skills and sensitivities than regular design from scratch; therefore additional tools are needed to cope with such projects. Herzog and De Meurons' comment on their work on the Tate Modern in London explains the difference. They claim that such projects require a very different kind of creative energy, which may be manifest as different kinds of knowledge, design tools, and design processes. We argue that such tools may be developed by reconstructing existing knowledge, disassembling the components of relevant precedents through a thorough analysis, and using these as stepping stones in the design process.

Adaptive reuse precedents have at least two phases (if not more) of physical existence: (1) The original design containing its original function; and (2) The new structure, containing its new function, after

the adaptive reuse process. Thus, adaptive reuse analysis is different and significantly more complex than the analysis of precedents that did undergo an adaptive reuse process. This leads to three stages of formal inquiry: (1) Original building form (original stage); (2) Reshaped building form (final stage); and (3) The transformation from original stage to final stage in terms of tactics, strategy, and type of intervention.

In order to learn from architecture design precedents, they must be searched for in an educated manner, based on multiple classification methods. Such search may be determined by the structure's original function, by name of architect, by formal attributes, and so on. The search for relevant precedents for an adaptive reuse project may become very complex since every search in any category mentioned above would definitely yield two (or more) different sets of data: The original function and the new function, the original architect and the intervention architect, the formal attributes of the original building and the formal attributes of the transformed building, and so on. In adaptive reuse architecture, the process of transforming the building, i.e. the tactics and strategy of transformation, is in itself an important precedent in architectural knowledge.

### Adaptive reuse architecture analyses

The mass, the size, the rhythm and the form of the existing building all provide opportunities for balance or counter points [4]. Brookner and Stone regard the analysis of form and structure of the existing building as fundamental to the intervention; No doubt, these are among the most important attributes to consider. Since we agree with Clark and Pause (1985) that architectural ideas exist in the world of space and form, we suggest a set of formal analyses based on the patterns of architecture they presented (1985), which focus on the physical structure. We also suggest classifying the variant precedents by strategy and tactics of refurbishment, and by the type of remodeling done. A comprehensive set of analyses is demonstrated on one case-study. We classify sixteen case studies according to the various categories, planting the seeds for the development of an automated adaptive reuse precedent search model [7].

### Documentation

Documentation is the basis for every study and analysis. Basic documentation in our study referred also to the urban context so as to capture the project's urban role. Images of the original use (when available) and the current, new use were used, as well as plans, sections and details from both phases of the structure's life. In addition, all case-studies' virtual models were drawn.

### Formal analysis in adaptive reuse architecture

The big challenge in the formal analysis of adaptive reuse architecture is the need to consider both the original building with its original use and physical structure, and the transformed building with its new use and new physical structure. In addition, there is the process of transformation or change to consider as well. The proposed analysis is composed of a formal analysis, whereby the same formal category is analyzed for both the original and the transformed buildings. Twelve formal categories were used in this research for the analysis, most of which were based on the work of Clark and Pause (1985) and Ching (1979), as follows: 1. Parti 2. Structure 3. Natural light 4. Massing 5. Plan to section/elevation 6. Circulation and used space 7. Repetitive vs. unique 8. Symmetry and balance 9. Geometry 10. Hierarchy 11. Additive-subtractive 12. Object and environment. A full, formal analysis and classification is demonstrated on the Caixa Forum in Madrid, redesigned by Herzog and De Mauron in (Figure 1).

### Strategies of remodeling

When a building is reused, the most important and meaningful factor in the design of the new building is the relationship between the old and the new. Brookner and Stone developed three categories or strategies of building reuse based on the extent of integration between the host building and the new elements. These strategies are intervention, insertion, and installation, as defined below:

**Installation** – The old and new buildings exist independently. The new elements are located within the boundaries of the existing building. Their design may be influenced by the existing building but they are not necessarily compatible with it. Upon removing the installations, the existing building may revert to its original state.

**Insertion** – A new, independent element that is suited exactly to the existing envelope. The element is constructed to fit and is located within the boundaries of the existing building.

**Intervention** – The existing structure undergoes major transformations so that it can no longer exist independently. The old and the new additions are completely integrated.

We used these categories, and added a scale ranging between “interventions” (the most symbiotic relationship) and “installation” (the most detached relationship). In some of our case studies we found it insufficient to classify a project into only one category, and so a diagram was attached to the three categories describing the relations between the old and the new masses, similar to the diagram suggested by Ching (1979), as illustrated in (Figure 2). A ranking system was also added, whereby each case study was ranked according to the degree of transformation it had undergone.

### Remodeling tactics

Tactics express the actual qualities of the building. The selection of details and style gives the building its character (Brookner & Stone, 2004). The tactics employed in the remodeling of a building can be seen as the elements or details that support the overall strategy. Brookner and Stone defined six tactics they claimed were consistently used in remodeling. Each of the 16 case studies treated here were examined according to them.

1. **Planes** define space. The various planes can control the visual and physical limits of the space.
2. **Light** controls space and form.
3. **Surface** is the tactile element that establishes a direct relationship between human contact and the building, using materials, ergonomics, etc.
4. **Objects** can manipulate space, movement, and visual directions. The objects can be of any scale or type and can enhance the space they occupy.
5. **Openings** are focal points in the building. They creates views, provide orientation, and establish relationships between spaces.
6. **Movement** can prove to be more than purely functional, forming sculptural elements and focal points within the building.

Figure 3 illustrates the tactics used by Herzog and De Meuron in the transformation of Caixa Forum, Madrid.

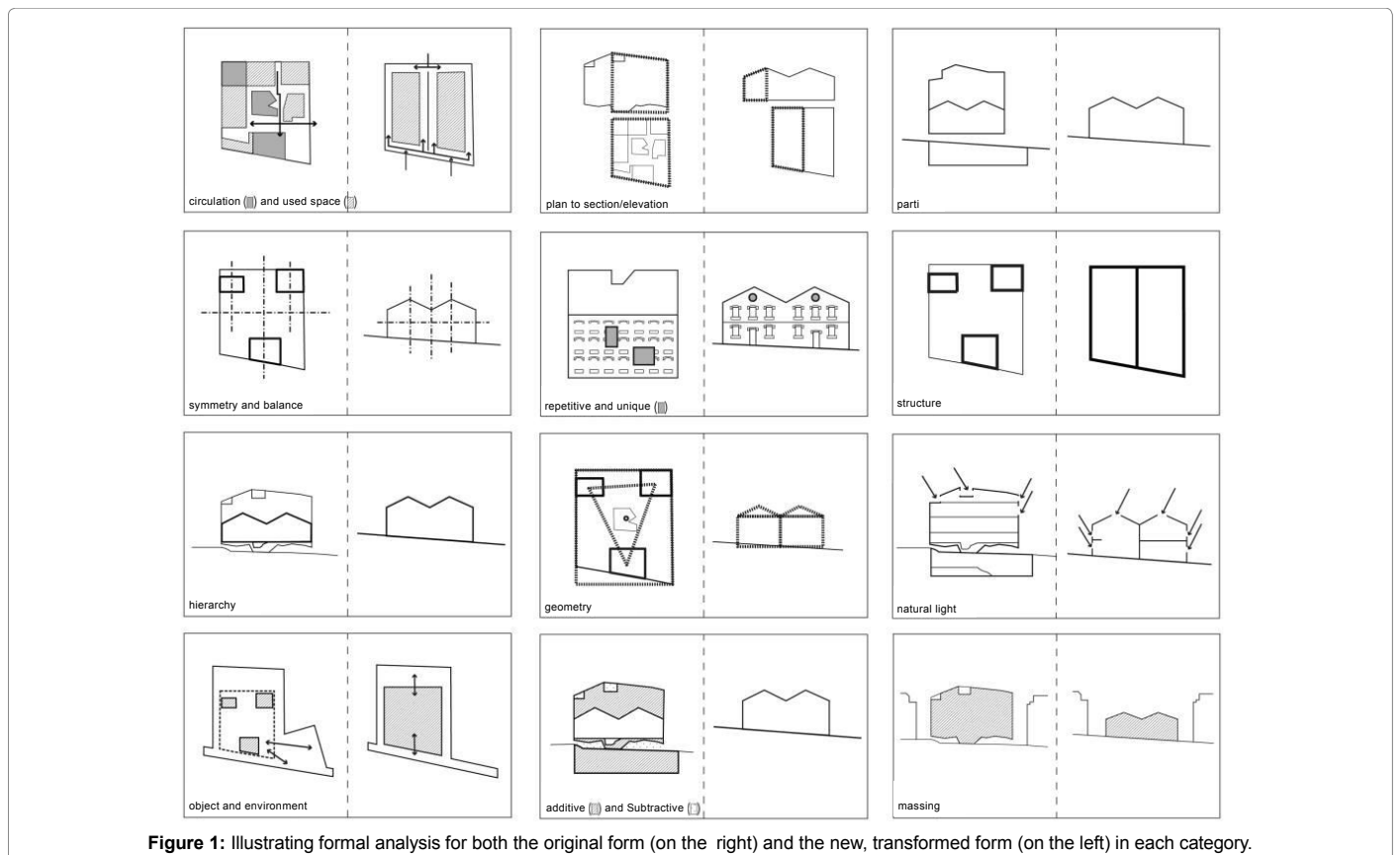


Figure 1: Illustrating formal analysis for both the original form (on the right) and the new, transformed form (on the left) in each category.

**Intervention types**

Adaptive reuse architecture is categorized according to the characteristics of the built mass, based partly on the works of Park and White, who suggested simple diagrams to interpret possible interventions and specific conditions for buildings and sites. Park highlighted the intervention as a dark scheme over a light outline diagram representing the existing building. In this work, we have added several possible diagrams, such as “Parasite” and “Filter”, to those suggested originally by Park. The intervention categories used in this work are as follows: Gate, Wall, Corner, Bridge, Transition, Joint, Boundary, Filter, Umbrella, Roof, Parasite, Hat, Divider, New interior,

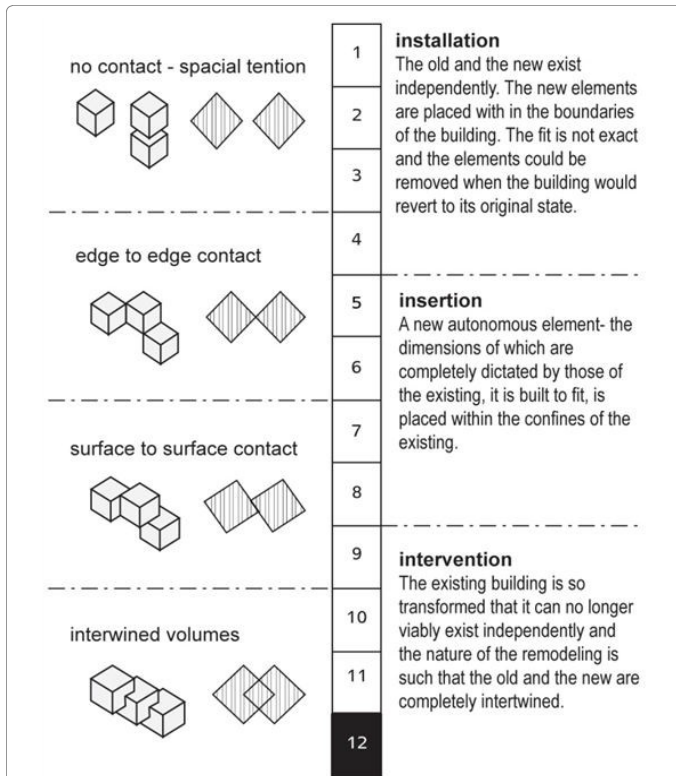
Skin, Glue, Feature, Infill, Underground, Alignment and Disalignment. Figure 4 compiles the relevant diagrams for all precedents, highlighting diagrams that are relevant for Chaixa Forum, Madrid [9,10].

**Classifying case studies**

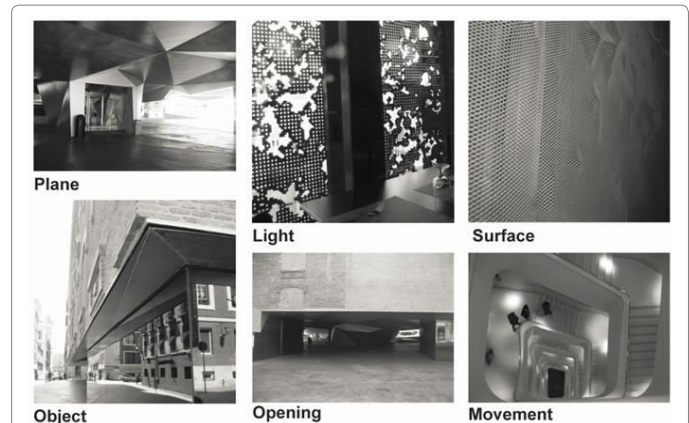
Figure 5 presents the sixteen projects that were part of this study. The projects are listed by name and location, remodeling architects, original and new uses, and remodeling year. As is evident even from this relatively short list of adaptive reuse buildings, the variety of reuse projects is rich and diverse in terms of the original uses of transformed buildings and their various new uses. Following are classifications by intervention strategy, tactics and characteristics of remodeled mass.

**Classification by formal analysis**

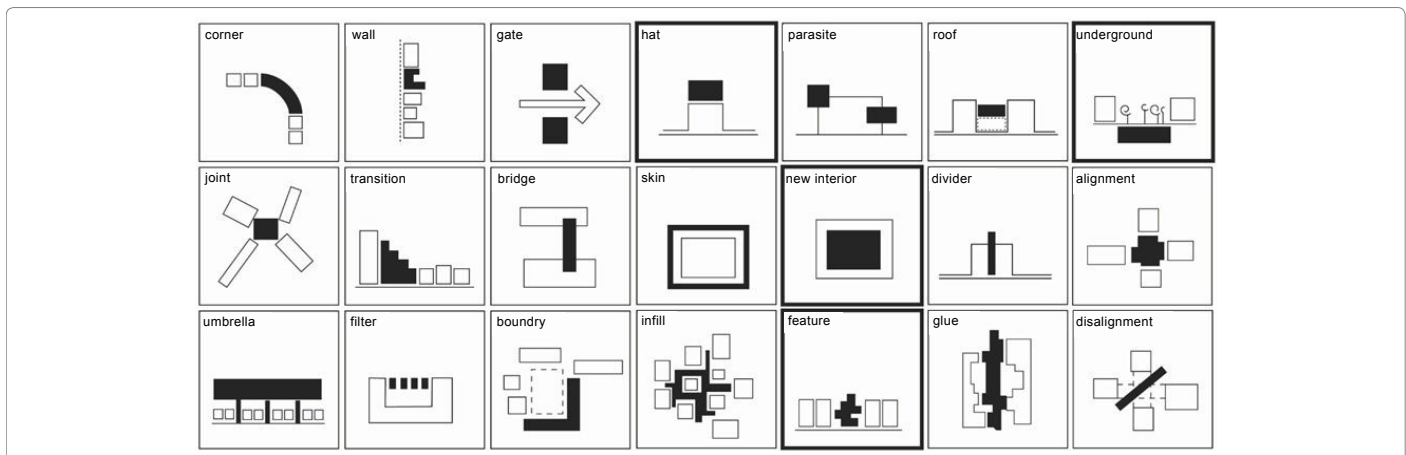
Comparative formal analysis for some case studies was conducted and projects were sorted into groups according to the different formal attributes of the two stages: the original building and the transformed building. In the example below, all formal representations of the massing are presented as well as a comparative representation of the old alongside the new (Figure 6). The question of change arises when the massing of the old buildings is observed versus the massing of the new buildings. The actions (or action) that created the change are more interesting than the actual massing at any stages, and so we examine the strategy and tactics of intervention to focus on such actions.



**Figure 2:** The extent of transformation of an existing building, including the three categories/strategies, four diagrams that illustrate the physical application, and a numeric scale that links the two measures.



**Figure 3:** Tactics of remodeling and physical attributes in Caixa Forum. Source: Photographs by D. Fisher-Gewirtzman.



**Figure 4:** compiles the relevant diagrams for all precedents, highlighting diagrams that are relevant for Chaixa Forum, Madrid. Based on O. Park.

Project	City	Architects of Remodeling	Original Use	New Use	Year
Caixa Forum	Madrid	Herzog & De-Meurom	Power station	Contemporary Art Museum	2008
Gemini Residence	Copenhagen	MVRDV	Silos	Housing	2001-05
Morgan Library	Manhattan	Renzo Piano, Beyer Blinder	Library, Housing	Library and Museum	2000-06
Elbphilharmonie	Hamburg	Herzog & De-Meurom	Storehouse	Cultural Center, Housing	2009-12
Dok Centrum	Delft	Dok Architecten, AEQUO	Offices	Media Library	2007
Embarcadero Civic Center	Caseras	Nieto Sobejano Arquitectos	Train Hangar	Cultural Center	2008
Bryant Art Center	Granville	Beyer Blinder	Sports Hall	Academic Center	2005
Punta Della Dogana	Venice	Tadao Ando	Store house	Contemporary Art Museum	2009
Tate Modern	London	Herzog & De-Meurom	Power Station	Contemporary Art Museum	1995-99
The Library For Children	Tokyo	Tadao Ando	Library	Childrens' Library	2002
Armstrong Oil Company	Denver	Lake-Flato	Machines Store	Offices (Oil & Gas)	2008
Urban Outfitters	Philadelphia	Meyer, Schere & Rockcasle Ltd	Ships Hangar	Offices (Fasion)	2006
Ford Assembly Building	Richmond	Marcy Wong Don Logan Arc.	Vehicles Factory	Cultural Center	2009
KuppershmuLe Museum	Daisburg	Herzog & De-Meurom	Sillos and Mill	Contemporary Art Museum	1999
Carmel Academic Center	Haifa	Knafo-klimor	Storehouse	Academic Center	2009
Reina Sofia	Madrid	Jean Nouvel	Hospital	Contemporary Art Museum	2005

Figure 5: List of precedents.

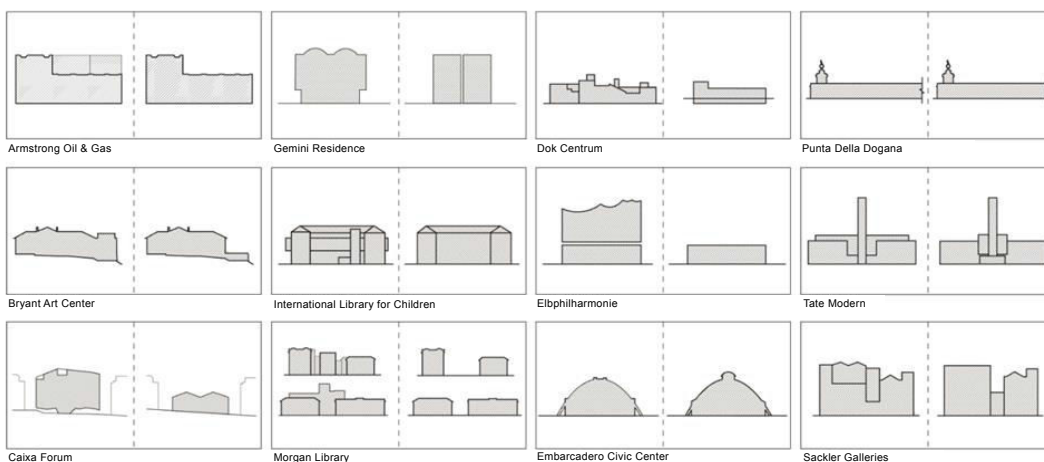


Figure 6: Formal representation of the massing of the old and new buildings for each project. (The old building is depicted on the right, and the new building is on the left).

### Classification by Strategy and Tactics of intervention

Figure 7 maps the strategies and tactics of intervention applied in the adaptive reuse precedents. The categories used here are based on Bruckner and Stone (2004). No clear trend can be seen but, we noted that only two of the sixteen case studies could be categorized as "Installation" while all the rest were categorized as either "Intervention" or "Insertion" [11,12]. We can therefore conclude that most projects involved a significant physical intervention. Upon examining the tactics applied in each case, it seems that in most case studies almost all of the defined tactics were used.

### Characteristics of the remodeled structure

Based on the type of intervention, we then mapped all sixteen projects, as illustrated in below figure. The main finding that is immediately evident from the table is that all projects but two have new interiors. The other types of intervention are applied in the various projects, each according to its relevance to the existing structure and the new demands (Figure 8).

### A search through precedents

Relevant precedents can be searched for in many ways as long as

strategy	tactics															
	rank	installation	insertion	intervention	plane	light	surface	object	opening	movement						
caixa forum	12															
gemini residence	8															
morgan library	5															
elbphilharmonie	10															
dok centrum	12															
embarcadero civic center	5															
bryant art center	8															
punta della dogana	1															
tate modern	8															
the library for children	9															
armstrong oil company	11															
urban outfitters	11															
ford assembly building	7															
kuppershmuLe museum	5															
carmel academic center	12															
reina sofia	3															

Figure 7: Map of the strategies and intervention tactics involved in the adaptive reused projects. Categories are based on Brookner and Stone (2004).



Figure 8: Six adaptive reuse projects with the same new function.



Punta Della Dogana Reina Sofia

Figure 9: Punta della Dogana by Tadao Ando and Reina Sofia by Jean Nouvel: Two projects in which the remodeling strategy was "Installation".



Figure 11: Caixa Forum, Elbphilharmonie and Tate modern: "Hat" intervention precedents.

project	gate	wall	corner	bridge	transition	boundary	filter	umbrella	roof	parasite	divider	new interior	skin	glue	feature	infill	underground	alignment	disalignment
caixa forum																			
gemini residence																			
morgan library																			
elbphilharmonie																			
dok centrum																			
embarcadero civic center																			
bryant art center																			
punta della dogana																			
tate modern																			
the library for children																			
armstrong oil company																			
urban outfitters																			
ford assembly building																			
kuppershmul museum																			
carmel academic center																			
reina sofia																			

Figure 10: Map of the interventions by type.

all of the data is interconnected through associative links regarding informative data, formal data, and data on the type, strategy and tactics of intervention. Figure 5 provides some basic information on the sixteen adaptive reuse projects examined here as explained in section 4. A typical search for precedents can start with the building's original use, for example "Industrial building". Our database of precedents contains two power stations and it appears that both were remodeled by the same architectural firm, namely Herzog and De Meuron. A search according to the two power stations' new function (Contemporary art museum) would lead to five projects: The Caixa Forum in Madrid, Punta della Dogana in Venice, Tate Modern, Kuppershmul Museum and Reine Sofia (Figure 9). These buildings were remodeled by different architects, are located in different places, had different original uses, and were subjected to different tactics and strategies in their redesign process [13-15].

The search for precedents can, alternatively, focus on specific intervention tactics or strategies, as illustrated in Figure 7. For example, projects whose strategy was "Installation" are Punta della Dogana by Tadao Ando and Reina Sofia by Jean Nouvel (Figure 10), while the "Intervention" strategy was applied to eight projects: Caixa Forum, Elbphilharmonia, Dok Centrum, the Library for Childrens' literature, Armstrong Company, Urban Outfitters, Ford Assembly Center, and the Carmel Academic Center. All of these projects were remodeled by

different architects in different countries and have different original and new functions. A regular search would not yield any connection between these eight precedents. Searching precedents by type of intervention is another way to learn about the variety of creative interpretations. For example, our case study precedents included three projects that involved a "Hat" type intervention, as illustrated in Figure 7. In this case, it is interesting to note that all three "hat" projects were redesigned by the same architects. Figure 11 presents Caixa Forum, Elbphilharmonie and Tate Modern. A rich and diverse search of relevant precedents always contributes to a good design process. The variety of search methods suggested above may contribute to complex adaptive reuse projects and enhance future design processes [16].

### Conclusions and Discussion

Learning from precedents is one of the most important knowledge bases for architects and for architecture students. Adaptive reuse architecture is a complex precedent to learn from, since there are more layers of knowledge than in any architectural project in which the physical and functional stages are fixed/remain unchanged. In such precedent cases, the original physical and functional stages and the final physical and functional stages are both relevant and important for the study, as are the decisions and actions that transform the form. Adaptive reuse precedents are extremely complicated to analyze and classify than other architecture precedents: formal analyses must be conducted, tactics and strategies of intervention are examined, and historical facts must be taken into account, such as when, where, who, and what. A multi-classification system allows for cross knowledge among many categories that enables to carry out a more powerful search.

Out of forty adaptive reuse projects analyzed and categorized, nineteen were originally industrial buildings. Thirteen were transformed into museums. Thirty- six out of forty redesigned the interiors using various tactics. Five out of the twenty one intervention types were not used at all and perhaps should be revisited. Significant intervention took place in most of the precedents. See Figure 12. A computerized system would update the graphs with every new precedent added to the system and enable an educated search in the E-learning process (Figure 11).

The categories in this paper are based on precedent work and may be expanded for future work in terms of category layers and relevant architectural precedents. Formal analyses focus on the most important categories but could get into more details. The interventions suggested here relate to the overall building and to its setting in the immediate

environment. These may develop into variant scales and solutions regarding the interiors as well. The input for such a system should be precise and structured and links connecting between all relevant data. Figure 10 is illustrating a possible format on each adaptive reuse precedent. In addition, a full 3D virtual model should be integrated as part of the learning process of the project. Figure 13 is illustrating a possible walk through an adaptive reuse precedent in an immersive visualization lab (Figure 12).

A progressive digital library that enables an automated precedent search for adaptive reuse architecture is the natural learning and working environment for this system. We hope to develop such a database as an open ended tool so that architects can add their projects to it and student conducting analyses can add the knowledge they collect. An open system would enable new uploads from future users and contributors. Such an educated precedent search may contribute to the adaptive reuse practice. Another possible future direction is the

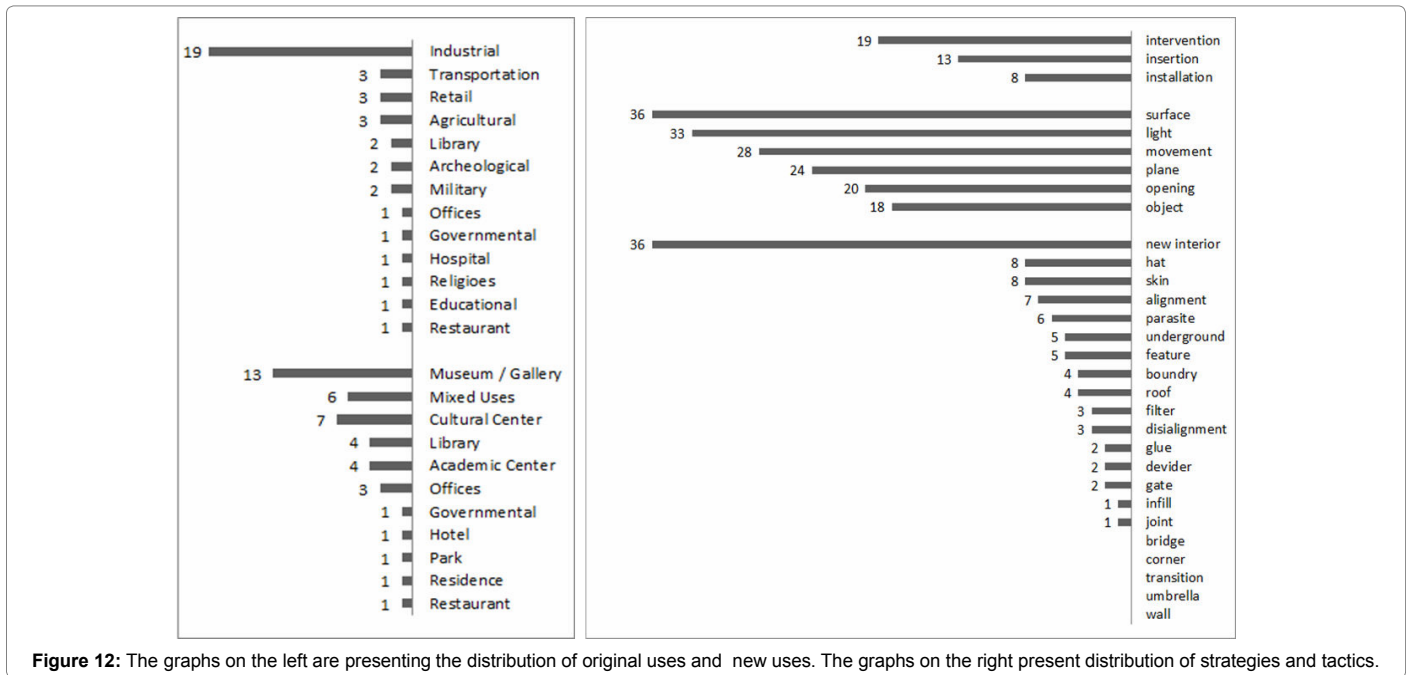


Figure 12: The graphs on the left are presenting the distribution of original uses and new uses. The graphs on the right present distribution of strategies and tactics.

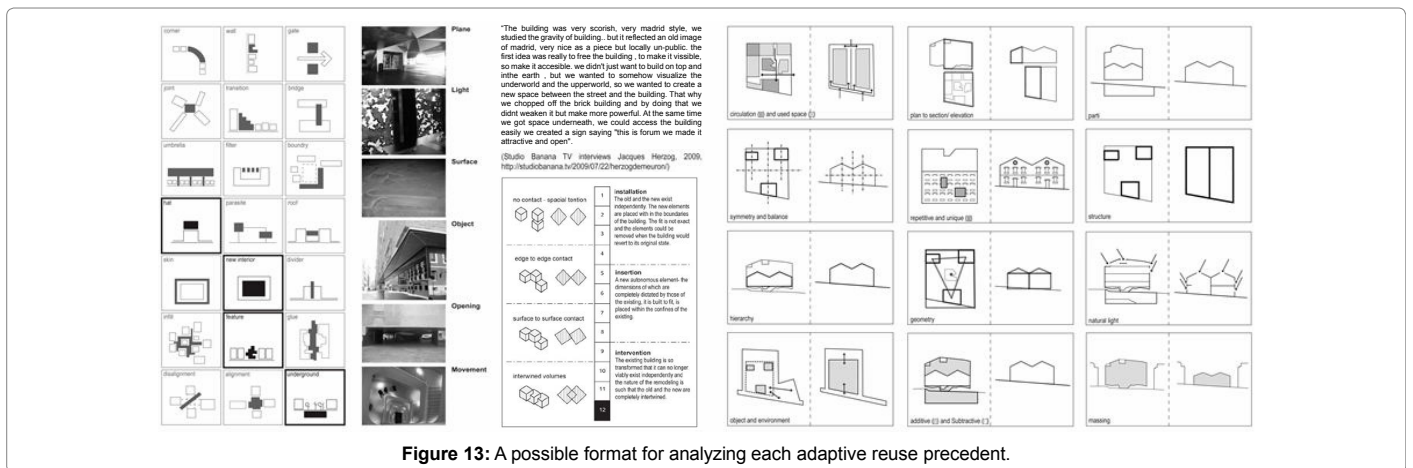


Figure 13: A possible format for analyzing each adaptive reuse precedent.

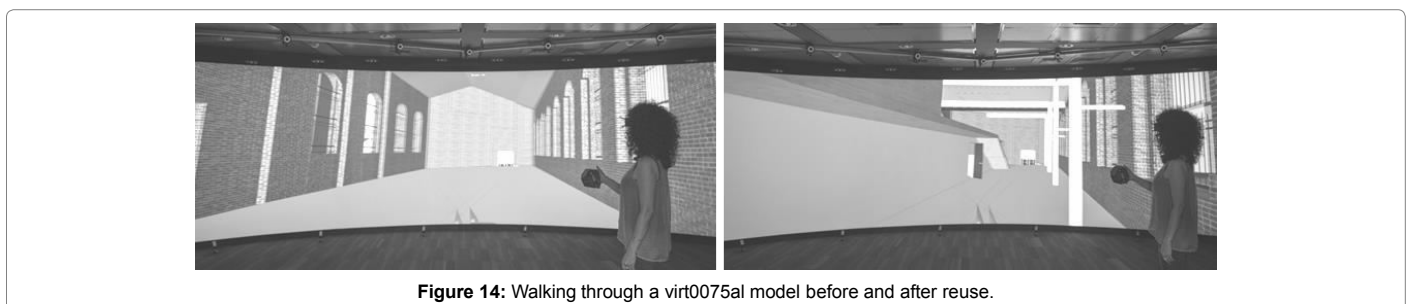


Figure 14: Walking through a virt0075al model before and after reuse.

development of a smart algorithm that supports a controlled design process for adaptive reuse projects by accompanying and reinforcing the free creative process (Figures 13 and 14).

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