Whole-to-Part-to-Whole: Co-Evolutionary and Integrative Design Approach

CASAKIN, Hernan* and GINSBURG, Yoram
Ariel University
* Corresponding author e-mail: casakin@ariel.ac.il

Forming designers in a fast-changing international scenario is a challenge for most schools and departments of architecture. It is in the design studio where students not only develop and apply analytical thinking skills, partly acquired in regular courses, but also abilities related to design synthesis and evaluation. However, a major question is how to effectively use knowledge and abilities in a manner that will lead to successful learning processes, and satisficing outcomes. To this aim, the Whole-to-Part-to-Whole Design is proposed in the architectural design studio as a catalysator of students’ capabilities, and as an approach for processing and integrating knowledge in a co-evolutionary way. A case study of a dwelling project is analysed to illustrate how the design approach is implemented. The paper discusses how the approach, can help to bridge the existing educational gap between analytical abilities and design skills. Pedagogical implications are presented.

design studio, architecture, co-evolution, knowledge integration

1 Introduction
Architectural schools and departments in universities around the world are facing the challenge of teaching designers in a fast-changing scenario. Students are expected to graduate with a well-balanced body of knowledge in a wide spectrum of domains, such as history, theory, technology, and design. Part of this challenge resides in the difference between learning in regular courses and in the design studio, considered as the core of the architectural studies (Goldschmidt, 2002). It is in this educational environment where students not only develop and apply analytical thinking skills, partly acquired in the different courses, but also abilities related to design synthesis and evaluation (Caliksan, 2012). Students are expected to acquire and integrate theoretical and practical knowledge (Sancar, 1996), develop their expertise and competence, and form their own ideas and judgments (Chastain & Elliott, 2000).

While students receive feedback from their teachers, they are engaged in a learning-by-doing activity that implies gaining knowledge and developing skills in a practical manner (Hinson, 2007;
Schön, 1987). A major difficulty, however, is how to effectively apply the expertise acquired in previous courses to fit it into the architectural design studio agenda, in a way that it will lead to successful design learning processes and satisficing (to use Simon’s notion) design outcomes (Goldschmidt, Casakin, Avidan, & Ronen, 2016) (See Simon, 1981, for further explanation about satisficing). In this sense, simply learning-by-doing does not automatically warrants that students will know how to efficiently use prior knowledge in order to make a coherent interpretation of the problem, and to produce an acceptable solution that is explainable and justifiable (Goldschmidt, 2014). Thus, in order to support the learning-by-doing activity, suitable approaches are crucial for facing these design education challenges. It is in the second-year design studio in the School of Architecture at Ariel University, where students must deal for the first time with a brief and a site simulating a real project in professional practice. Therefore, a major goal is to harvest what they achieved in the first year with regard to the sensual and conceptual perceptions of architecture, and integrate these into real practice. To this aim, design tools from both the conceptual and the practical spheres should be delivered to students to allow them to advance their own agenda.

The Whole-to-Part-to-Whole: Integrative and Co-Evolutionary Design is an approach that seeks to relate and integrate the variety of layers of knowledge acquired by students both in the architectural courses, and in previous design studios in a systematic and creative way. The approach aims at helping students to enhance their analysis, synthesis, and evaluation capabilities (Eliouti, 2009) during the design process in a non-linear, iterative and developmental way. This approach was developed through the last five years, and implemented by the design of a mixed-use complex of dwelling units.

The design of residential units, representing approximately 75% of the urban fabric in the contemporary city, is considered as one of the most complex topics of architectural education. It is part of a triangular matrix of the following systemic interrelationships: i) the residential building, the street and the neighbourhood; ii) the residential unit and the other units; iii) the spaces and functions of each residential unit.

The paper describes the proposed educational approach its context, and major focus. Thereafter, it introduces the housing project carried out in the design studio, the intended aims, and the timeline for the different phases of the project. The final part illustrates and analyses the work of a student. This is followed by a final section discussing how the approach can help to bridge the existing educational gap between analytical abilities, and design thinking skills. The paper concludes with a focus on the aspects that went well, as well as what needs to be improved in the future.

2 The Integrative and Co-Evolutionary Design Approach

The Whole-to-Part-to-Whole: Integrative and Co-Evolutionary Design is an approach that seeks to integrate the different layers of knowledge acquired in previous courses in a systematic and creative way. An important feature is concerned with the zoom-in and zoom-out scaling strategy. Part of the complexity of the mixed-use project, consists in coherently designing non-repetitive dwelling units at the urban, architectural, and interior design scales. To this aim, the approach encourages students to combine divergent thinking with convergent thinking at the distinct phases of the design process. This is achieved by means of a series of analysis, synthesis, and evaluation cycles (Eliouti, 2009; Jones, 1980). While using divergent thinking, students are encouraged to explore, and analyse as many idea solutions as possible in terms of their suitability to the design goals. In the convergent thinking mode, they are requested to come up with a few alternatives, which leads to a final solution (Liu, Bligh, & Chakrabarti, 2003). Design decisions are evaluated against design requirements in a cyclical non-linear fashion. In this way, students can modify their solutions at any stage of the process by keeping consistency through the different design scales.
2.1 **Design Approach: Focuses and Tasks**

Whereas the design approach promotes the use of divergent and convergent thinking at any stage of the design process, it also focuses on the following key aspects:

2.1.1 **Contextual analysis**

People’s culture and lifestyle is strongly linked to places. Certainly, the inseparableness of the human being and place is a central issue of debate in the design project. While the environment is being more and more degraded, architecture has an important function in contributing to identifying and strengthening the ‘genius loci’ and spirit of place (Norberg-Schulz, 1982). We expected that the analysis and understanding of the fundamental features of each site (Lynch, 1985), would be critical to produce radically unique design solutions in each selected site, even that all projects shared a same design brief.

2.1.2 **Problem definition and conceptual thinking**

A most important stage is to frame the design problem, which structure and inform the design task (Lawson & Loke, 1997; Newell and Simon, 1972). In contrast to site analysis that is concerned with a concrete and detailed reality, problem definition is mainly related to the understanding of critical aspects of the design situation. Accordingly, students were requested to reflect on their design intentions, define initial goals, and deploy conceptual thinking (Goel, 1995).

The generation of design concepts was supported by a series of design exercises to produce mental maps (Jeffery & Burgess, 2006). These are abstract two-dimensional subjective representations of the site (Lynch, 1960) that were used to put in relevance major spatial issues as perceived by the students. The emergent mental image contributed to structuring the design problem (Casakin, 2008; Konar & Chakraborty, 2005).

2.1.3 **Problem solving skills, and idea generation**

Designers usually work by jointly understanding and framing the problem, and generating solutions (Lawson & Loke, 2004). Thus, the next stage consisted in helping students to develop their problem-solving skills when producing alternative design ideas about their personal understanding of ‘dwelling in the contemporary city’ (Perttula & Sipila, 2007). To this aim, they first built conceptual mock-ups disregarding the scale of the physical site. Thereafter, they produced 1:250 mock-ups that helped test their ideas in the selected site.

2.1.4 **Inspiration sources and idea generation**

The generation of ideas was stimulated using within-domain and between domain images as metaphorical and analogical sources. Exposition to visual stimuli enhanced the chances to enhance the quality of the design solutions (Goldschmidt & Smolkov, 2006). A major challenge, however, was how to help students identify and retrieve relevant concepts from the images, and adapt them to the design project without becoming fixated (Cardoso & Badke-Schaub, 2011). To this end, students were trained to retrieve analogical and metaphorical principles from visual images, which also served as inspirational sources for their projects (Casakin, 2005; Gonçalves, Cardoso, & Badke-Schaub, 2014).

2.1.5 **Precedents as inspirational sources**

These tools are specific designs that are exemplary in some way, and thus it is possible to learn an important lesson from them (Akin, 2002; Clark & Pause, 1985; Lawson, 2004). Precedents are existing solutions generally produced by master designers in reference to specific design problems, which were used by students as examples of imitation, and as sources of inspiration for their own designs. The Whole-to-Part-to-Whole approach encouraged to continuously use precedents at every stage of the design process, and at different scales of the project (e.g., either a façade or a construction detail).
2.1.6 Speculations on design form - morphology and façade

The city’s morphology, and specifically the immediate context where students intervened, is the outcome of cultural and socioeconomic dynamics. The context, architectural brief, and the personal beliefs and goals of the students were the three major determinants of the building form. The way that these elements interacted along the process affected the resulting morphology of the project, including the external volumes and the façades. The dialogue established between the housing project and its context, and the meaning of good city form (Lynch, 1984) was another concern. For example, whether the morphology and facades of a building should imitate or contrast with the genius loci of place (Norberg-Schulz, 1991) was a crucial question. In this regard, students used between-domain displays to analyse structural relationships established between external form, and interior space of an object (Ching, 2007). This enabled students to continue developing their abstraction and analytical skills, and to enhance the visual quality of their projects.

2.1.7 Speculations on function and organization

The role of functionalism in a building can be traced back to the Vitruvian triad, in which ‘utilitas’ (convenience or utility) stands alongside ‘venustas’ (beauty or aesthetics) and ‘firmitas’ (firmness or structure), known as one of three typical goals of architecture. The function or purpose of a building, dwelling units in this case, has always been a key issue affecting the external appearance and the organization of internal spaces (e.g., Cherulnik, 1991; Nasar, Stamps & Kazunori, 2005). An important aim of the learning process was to help students deal with a complex program consisting of non-repetitive units. Two complementary mechanisms were employed to this end. One that served as control, and determined the number of units, the maximum square meters allowed for the functions and for ground level occupation, and the maximum volume of the building. In contrast, the other mechanism was non-restrictive, and aimed at giving freedom to organize different dwelling units according to individual programmatic goals and needs. The aim was to discourage the design of repetitive units, and to promote the exploration of atypical dwelling units, for the sake of reformulating the notion of contemporary dwelling.

3 Method

3.1 Participants and set up

Twenty-six undergraduate students from architecture in their second year of studies were enrolled in the design studio. The students work individually, and were unaware of the goals of the study.

3.2 Task and procedure

The task called for the design of a mixed-use project consisting of 8 to 10 non-repetitive dwelling units, and a small public building located in a controversial urban area of Jerusalem city. Students were requested to visit, analyse, and select one of three sites located in different contexts of the city that included: a peripheral neighbourhood, an historical quarter, and a central business area.

It was specified that the design should account for several environmental and contextual aspects, such as the ‘genius loci’ and historical development of place, typology of existing buildings, morphological language, public spaces, orientation, topography, views, and bio-climatic conditions, materials and technology, cultural and spatial behaviour. Other aspects concerned with the building and its context included: interior vs. exterior; open vs. closed spaces; private vs. public spaces; function, structure, and shape; horizontal and vertical circulation schemes. It was expected that students would be able to define a new design language for the housing project alternative to the existing one. Table 1 shows the timeline assigned to students for the development of the project, and the phases of the design process, including intermediate reviews, and the final presentation.
Table 1  
**Timeline, design activities, and lectures presented during the development of the mixed-used project.**

<table>
<thead>
<tr>
<th>Meetings</th>
<th>Hours</th>
<th>Design activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 3</td>
<td>22</td>
<td>Introduction of the course + Visit to Jerusalem: analysis of three intervention sites + iconic dwelling buildings + Site selection + Mental map</td>
</tr>
<tr>
<td>4 - 7</td>
<td>20</td>
<td>Development of project in 1:250 – conceptual and concrete models + site model</td>
</tr>
<tr>
<td>8-9</td>
<td>10</td>
<td>First intermediate presentation: urban design scale – 1:250</td>
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<tr>
<td>10-11</td>
<td>10</td>
<td>From urban to architectural scales - 1:250 to 1:100. Design brief analysis – dwelling types and users – the architectural envelope</td>
</tr>
<tr>
<td>12-16</td>
<td>20</td>
<td>Development of project in 1:100 – the internal functioning and organization of the dwellings and their relations with the exterior</td>
</tr>
<tr>
<td>17-18</td>
<td>10</td>
<td>Second intermediate presentation: architectural design – 1:100 and its influence on 1:250</td>
</tr>
<tr>
<td>19-20</td>
<td>10</td>
<td>From architectural to interior design scales - 1:100 to 1:50</td>
</tr>
<tr>
<td>21-23</td>
<td>15</td>
<td>Development of selected parts of the project in 1:50 – spatiality and interior design: furniture, materiality, technology</td>
</tr>
<tr>
<td>24</td>
<td>5</td>
<td>Third intermediate presentation: interior design – 1:50 and its influence on 1:100 and 1:250</td>
</tr>
<tr>
<td>25-26</td>
<td>10</td>
<td>Integration and development of the project in the three scales</td>
</tr>
<tr>
<td>27-28</td>
<td>12</td>
<td>Final presentation (two weeks after meeting 26)</td>
</tr>
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</table>

4  
**Project outcome**

In order to illustrate the outcomes produced in the design studio, we present and analyse the work of Avihad as a case study. Avihad worked in Kiryat Yovel, a densely populated neighbourhood in southwest Jerusalem area. Historically, the neighbourhood served as a shelter for those who had nowhere to go. In the 50s’, a number of housing projects were rapidly built by the government in order to provide accommodation to the torrent of immigrants and refugees. These were characterized by small and repetitive dwelling units - about 40 to 60 square meters, and very basic facilities. With the years and the economic progress, many families left the place and moved to other better areas in the city. However, those who remained failed to develop roots, and till today they see the neighbourhood a temporary place. Partly for these reasons, Kiryat Yovel suffers from a lack of maintenance and attractiveness for potential new residents.

Thus, a major goal of the project was to reverse the situation by designing new residential units and public facilities that should be attractive for more well-off groups of families. The brief called for the design of a variety of typologies of varied sizes that should be suitable for a range of users. Eventually, when families would grow, they would be able to move to other units in the same building.

The analysis of the project is organized into the following stages of development: i) problem definition and concept generation; ii) approach to urban scale: the dwelling project and the neighbourhood; iii) approach to architectural scale: the housing project and the dwelling units, and iv) approach to interior design scale: the dwelling unit -spaces and functions.

In the problem definition and concept generation phase, Avihad analysed the physical and sociological context from objective data. Thereafter, he produced a mental map of the area, illustrating his personal and subjective interpretation of the site, that included a diagnosis of major conflicts and design intentions. The understanding and ideas that emerged from the mental map, were explored further by the use of abstract mock-ups. At this stage, the student was expected to elaborate and discuss his initial design ideas in 3D. An outcome of this was a mock-up representing an inter-play of vertical and horizontal elements that served as connectors between public spaces along the floors of the building (See Figures 1a and 1b). The proposed idea suggested alternative spaces to the existing housing project, and public meeting areas.
In the next stage, the student continues redefining the problem and exploring his design ideas at an urban scale. To this end, he constructed a series of 1:250 mock-ups of the site to test alternative solutions. The urban scale was appropriate to elaborate further on his personal beliefs and goals, before dealing with the detailed brief of the project. Avihad's central design idea was to keep alive the collective memory of the place by integrating the new dwellings with the existing slab. He also proposed adding public functions to strengthen the interaction between the neighbours. To this aim, he designed a park, a small commercial centre, and a play area for kids (See Figure 2a). The use of historical precedents helped him to design a colonnade street, that served as a transition zone between the exterior and the interior of the building, and provided shadow to the entrances of the different units and the public zones (See Figures 2b).

![Figure 1: Conceptual model – composition of horizontal and vertical elements: plan and view. Source: Avihad Fried](image)

![Figure 2: The housing project and the physical environment a) ground floor plan in 1:250; b) colonnade street. Source: Avihad Fried.](image)
Precedents and images about bridges served as inspiration sources for another design goal: due to the dramatic topography of the site, he decided to use the building as a connector between the lower and the unconnected higher levels of the neighbourhood. In this way, the metaphor ‘a housing building as a bridge’ led to the free transit of residents and visitors through the housing project (Figure 3).

Regarding the collective memory of the place, another design goal was to preserve the rhythm of the façade and the vertical circulation piers of the existing slab. This leads to another metaphor referring to the circulation piers as huge public lanterns. The figurative concept was implemented by illuminating the different floors by means of monumental skylights situated above the vertical shared public spaces. Moreover, in order to articulate the monolithic volume of the slab, and in analogy to a ship image, the building was divided into three major parts: the lower one corresponding to the larger dwellings, the higher one combining dwellings with offices in the last floors, and the central one was conceived for the commercial area, as illustrated in the working model in 1:250 (Figure 4).

The next stage was a transition from the urban to the architectural scale. It focused on the relationship between the building and the dwelling units, and therefore the student worked at 1:100 scale. After learning the design brief, he analysed spatial and functional needs of the dwelling units. This was supported by external images that included housing typologies, which served as consultation sources to the design problem. In this stage, a major challenge was to deal with the design and organization of the units without disregarding the goals and ideas developed at the urban scale. The example of Le Corbusier’s semi-detached houses served as an inspiration for the design: whereas externally the image of the existing slab was preserved, internally the new dwelling units were designed as open-ended systems partially detached from the façade. Consequently, a double skin façade containing passages and public spaces was created along the building (See Figure 6c).

The design strategy enabled the units to grow internally according to their present and future needs,
and converted the façade into a 3D ‘latticework’ filter that generated an inter-play of light and shadow (Figure 5).

![Figure 5: Dwelling floor plan in 1:100. Source: Avihad Fried.](image)

Variations in materiality was used as a concept to stress the rhythm of the façade. The combination of materials was used to differentiate the legibility of the dwelling units – mainly characterized by

![Figure 6: Façade of the building: a) front view; b) modularity, materiality, and depth of the façade; c) double skin façade containing circulation and semi-open public shared in 1:100. Source: Avihad Fried.](image)
wood and stone, from the public zones – i.e., entrances, commercial areas, and offices - characterized by glass curtain wall and concrete (See Figures 6a and 6b). New questions about the external image were raised at this stage of the process, which led to the redesign of the building at the urban and architectural scales (Figure 7).

Figures 8 and 9 depict the situation of the site, and how it was modified after the project intervention. In the photomontage it can be observed how a new layer of modernity was added, while the identity and collective memory of the existing building was preserved at some level of abstraction (Figure 9).

The stage that followed was a transition from the architectural scale to the interior design of selected dwelling units, where the student worked at 1:50. He explored the technology and materiality of the different spaces that also included furniture, texture, and colour. Figure 10 shows an example of the design of two dwellings: one is a duplex unit, and the other is a dwelling for a family with two kids, one of whom is handicapped. A major goal at this stage was to confer a unique identity to each unit, without disrupting the composition of the morphology and the façades.
Figure 9: Photomontage showing the new housing project in Kiryat Yovel. Source: Avihad Fried.

Figure 10: Interior design: a) floor plan of two dwellings; b) Internal view of the library in the right-side house; c) Internal view of the double space in the left side house. Source: Avihad Fried.
In sum, the proposed design approach aided to reflect about the project, bearing in mind the integration of solutions at different physical scales. The development of the design outcomes was achieved in an iterative and co-evolving way along the process, till a final solution was reached.

5 Reflections of what went well and what went wrong

The Whole-to-Part-to-Whole: Integrative and Co-Evolutionary Design approach was proposed as a catalyst of design student capabilities. The approach was intended to help students consolidate and enhance the knowledge acquired in the architectural courses, and in previous design studios. The method aimed to reduce the current educational gap between analytical abilities generally taught in the courses, and design thinking skills acquired in the 2nd year design studio, mainly dealing with analysis, synthesis, and evaluation. While simulating the design activity as if carried out in real professional practice, the approach attempted to make another step forward to integrate theoretical with practical knowledge. Specifically, the approach facilitated the means to reflect about individual design intentions, and define design goals. Consequently, students managed to identify and structure the critical aspects of the dwelling design problem. The use of inspiration sources such as images and drawings, were essential to establish metaphors and analogies with the design problem. In this regard, the identification and transference of analogical and metaphorical principles was highly efficient for the production of creative design ideas and solutions. In addition, the employment of precedents and building typologies as sources of knowledge also contributed to deploy conceptual thinking along the design process. Existing solutions made by master and well known architects were used by students as examples of imitation and assessment of their own projects. Making abstractions of these and other sources like analogies and metaphors, and applying the retrieved design principles to the architectural design problems showed to be critical to bridge the gap between analysis, synthesis, and evaluation capabilities.

Moreover, the method supported the development of the design task at incremental levels of detail, through the different scales of the project. Working in a zoom-in and zoom-out modality, from the whole to the parts and vice-versa, aided to deal with the complexities of the design task and understand the intricate system of relationships established between and within the different scales of the project. Consequently, a major input of the approach was to systematically deal with a multifaceted design process in a relatively short period of time, enhance design expertise, forge individual judgment independently of the guidance provided by the tutors, and finally arrive at creative design outcomes.

Besides these important achievements, there is still room for improvement of the design approach in a number of aspects. One concern is how to effectively collect and apply to the project the information obtained from site analysis. Although this is an essential stage of the design process, a major difficulty resides in identifying relevant data, and in operationalizing it to suit personal design intentions in practice. We realized that not all the information collected during the site analysis showed to be significant or useful for the design project. This can be attributed to the difficulty of filtering information, and shifting from divergent to convergent thinking. We suggest that in future projects, site analysis should be more informed by individual motivations and subjective interpretations of the data, than by an objective and rational analysis of data. This would help to guide divergent and convergent thinking in a more personalized and efficient way.

Another issue is concerned with time management and coordination of the different design activities carried out during the project. A conflict between the extended design agenda and the time limitations forced the teachers to move ahead fast in order to comply with the planned schedule, sometimes before completely achieving the goals set for a particular stage. A fine tuning of the agenda in coordination with the timetable will allow refining further the design approach, and establishing a clearer hierarchy between primary and secondary goals.

Whereas the design approach demanded from students integrating their solutions at the urban, architectural, and interior design scales, another major difficulty was how to develop and adjust the
project at each of these scales without altering original design goals and intentions. For example, a typical problem was how to coordinate design actions for organizing the non-repetitive and atypical dwelling units, while caring at the same time for the design of common vertical circulations, shared structure and ducts, and the legibility and aesthetic harmony of the building. Although useful and stimulating, adapting and transforming information from precedents and other visual sources to the design project showed to be another difficulty demanding a level of expertise that not all students always had. It is possible that in order to develop such design skills in the future, the approach should include a series of short exercises to learn how to map and adapt information from visual sources represented at different level of detail, to the problem at hand.

The method, which was applied to the design of a mixed-used housing project, will be implemented next semester in the design of a public building. Together with this, in a following study we plan to carry out a survey with the 2nd year architectural design students in order to gain further insight into their perceptions about the proposed design approach. In particular, we would like to learn more about the potential strengths, weaknesses, opportunities, and threads (SWOT) that the method could involve for enhancing education in the design studio.

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6 References


About the Authors:

**Hernan CASAKIN** had appointments as research fellow in Hamburg University, Tel Aviv University, and TU Delft, Delft University of Technology. He is a board member of several international journals. His research interests are in design thinking, expertise, design education, and creativity.

**Yoram GINSBURG** is an independent architect specialized in regional and urban planning, and in public and private building. He is a senior lecturer in urban planning and design studio courses. His research interests are in theory of place and locality in architectural and urban planning.