29 Prototypes, Variation, and Composition:

A Formal Design Approach in Urban Housing Design with Computer Assistance

Mao-Lin Chiu
Dept. of Architecture, National Cheng-Kung University, Tainan, Taiwan

This paper outlines a formal design approach for teaching 3D modeling in computer-aided architecture design studios, and various design principles are used in the process, particularly the generalization, variation and composition.

The teaching agenda includes:

(1) a formal design approach of housing design,

(2) design collaboration, and

(3) computer-aided architectural design.

The research agenda includes:

(1) incorporation of the formal design approach with the urban infill theory, and

(2) development of a computational design method.

The studio project is demonstrated to highlight the implementation of the approach.

KEYWORDS: Computer-aided design, prototypes, housing design, formal design method

1.0 INTRODUCTION

Design is an evolutionary process, and various design principles are generally used in the process, particularly the generalization, variation and composition. In general, architects or designers receive design requirements from their clients, then formulate the architectural program based on the requirements. Design guidelines are used to facilitate design solutions, and are a set of design principles or rules which define the conditions to satisfy the design constraints such as the site boundary, floor area ratio, building height, or setbacks. The basic design guidelines are generally decided by explicit or implicit values.

Meanwhile, design prototypes are typically used to represent specific design knowledge. A design prototype brings together the requisite knowledge appropriate to a specific design situation [Gero 1990]. Some design prototypes are generated or derived based upon the previous instances or experience. According to specific constraints or preferences, variation of prototypes and composition are further generated.

The above scenario can be generalized as shown in Figure-1, the procedure starts from giving requirements, defining design guidelines, developing design prototypes, variation, to composition.

Figure-1: The formal design approach

To demonstrate the changes during the process, 3D modeling is a fundamental design skill. This paper outlines a plan for teaching 3D modeling in computer-aided architectural design studios with a formal design approach. The following sections will address the teaching and reseach agenda carried out in the CAAD studios, and followed by the demonstration and findings.

2.0 THE TEACHING AGENDA

Today, in the electronic era, how to combine computational skills and design principles and methods in the teaching agenda is critical to our educational goals. Particularly, in the computer-aided design studios, the emphasis is not simply using computers to capture images or reproduce drawings, but also intending to merge computational methods with design thinking.

Therefore, "design prototypes" are proposed to used as the conceptual models of housing units. Particular interests are to form constructive analysis of the urban housing system. The SAR theory provides the foundation for supporting the urban "infill" strategy [Wiewel 1976]. Thus, variation can be made by retrieving and modifying the prototypes. In this case, prototypes were constructed by design guidelines derived from previous studies. Design development with adoption of prototypes can varies from a single housing unit to row houses as needed. In the studio, students learn from the exercise of development of design guidelines, prototypes, variation, and composition.

The teaching agenda as proposed includes:

(1) the urban infill theory,

(2) design collaboration, and

(3) computer-aided architectural design.

The collaborative design studio (CDS) had tried successfully in the previous exercise to allow students work collectively in a large scale of site, and share ideas and reflection on the internet [Chiu 1995a, 1995b]. The CDS were organized as part of the CAD studios in collaboration with other institutions. One undergraduate and one graduate computer-aided design courses are given at the same time. However, two courses have different emphasis. As shown in Figure-2, the graduate course focused on the development from requirements, design guidelines, to prototypes., while the

undergraduate course focused on the development from prototypes, variation, to composition. This paper will focus on the undergraduate course.

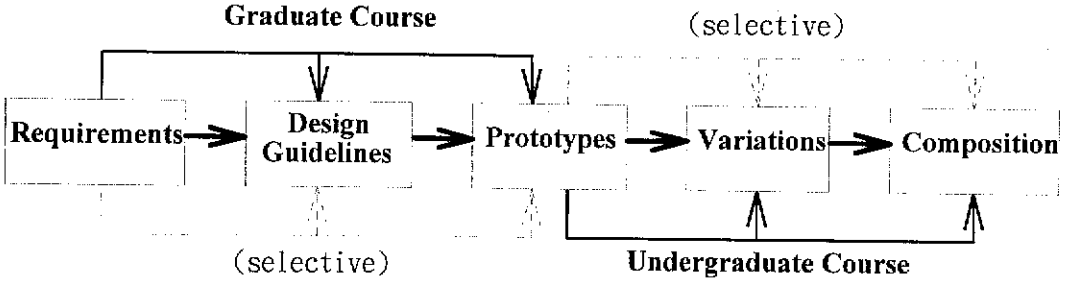

Figure-2: The teaching focuses of the formal design approach

Furthermore, CAD programs with 3D modelers offer some basic capabilities that seem particularly suitable for the constructive analysis of given designs [Flemming 1990]. 3D modeling with computer assistance was found useful in variation and composition. To distinct panel and mass architecture, students was instructed by learning the basic 3D modeling skills such as surface and solid modeling. Compositional principles in surface modeling are such as attachment, connections, and enclosure, and in solid modeling are such as union, intersection and difference. The CAD tools include AutoCAD, ArchiCAD, 3D Studio, Photoshop, etc. The exercises are carried throughout the course.

3. THE RESEARCH AGENDA

The teaching agenda provides the foundation for the educational purposes. The research agenda is accompany with these exercises to discover the effectiveness of the computational design method. The research agenda includes:

(1) incorporating the formal design approach with the urban infill theory, and

(2) developing a computational design method.

A design guideline was originally developed for the collaborative design studio among National Cheng Kung University (NCKU) and National Taiwan Institute of Technology (NTIT). The draft was further developed to enhance the possibility of computational methods, i.e. design prototypes and parametric design. A design prototype has to solve functional requirements and its internal relations. Therefore, a design prototype is a conceptual schema for representing a generalized building elements and design principles.

Site subdivision is an important step to define the scale of block and problem. Figure-3 demonstrates two alteratives in site subdivision. Converting design requirements into design guidelines requires design thinking. Figure-4 shows the change, and the details of supports and infills was defined in Figure-5.

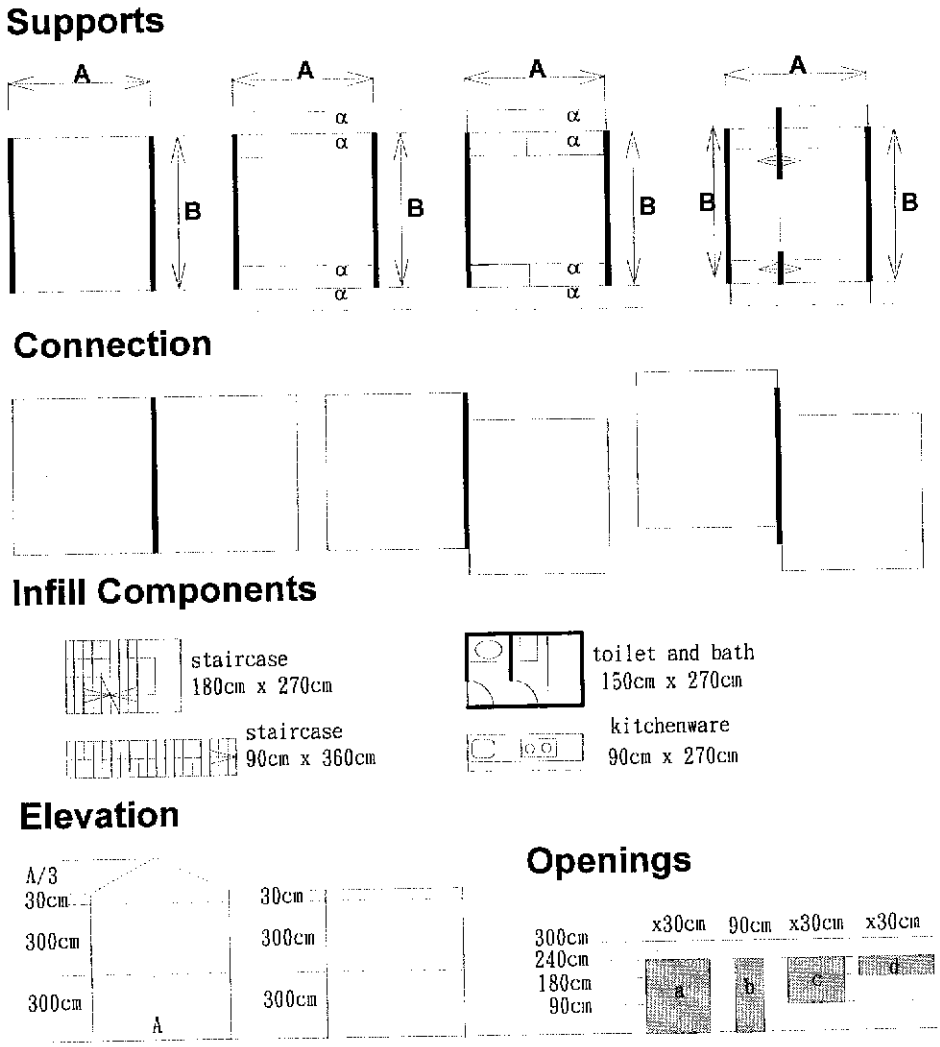

Figure-5: The Supports and Infills

The formal design approach described above was further developed as two parts:

1.) a top-down process of analyzing design cases or the precedents to demonstrate underlying principles, rules and spatial relations, design prototypes can be modeled, and dimensions can be converted into parameters as shown in Figure-6;
2.) a bottom-up process of modeling artifacts from parts or units to integrated works, the relations between supports and infills, and components can be defined.

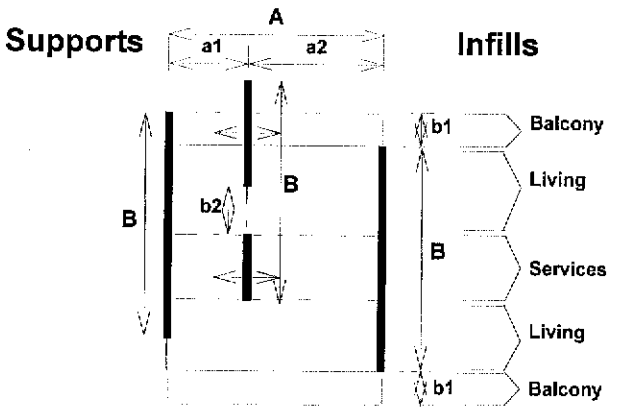

Figure-6: Parametric design of the Supports

4.0 THE DEMONSTRATION

The approach was applied to several projects undertaken in both the undergraduate and graduate courses. However, the following demonstration focuses on "the virtual community" undertaken in the undergraduate course. The studio project is proposed to design a faculty housing community near NTIT.

Figure-7 illustrates the project site which was carefully subdivided for implementing the infill scheme, and was divided into three building types - A-type (6m x 21m), B-type (9m x 21m), or C-type (18m x 21m). Two institutions were participating development of the community. Each student at NCKU chose either an A-type or a B-type unit and designed a row house. Students were advised to develop the standard unit first, then the corner unit which is located on the corner and its width is longer than the standard unit by 1.5 meter.

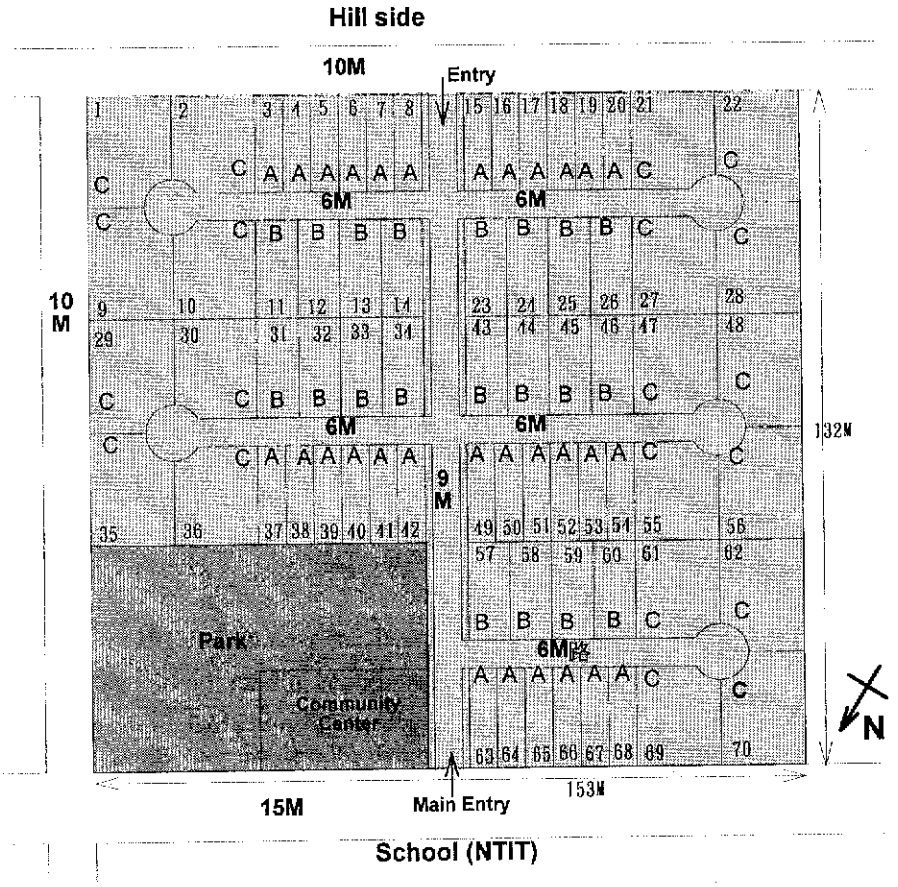

Figure-7: The Project Site

To facilitate the development of design prototypes, two cases of each type are provided from empirical studies as shown in Figure-8. This strategy is to experiment recalling design cases and adapting in new cases. Students can choose either one or do not choose both two cases, but develop their own type. Indeed, this strategy is found to be useful and shorten design reasoning time. Most students developed prototypes based on selected cases. Figure-9 and Figure-10 demonstate that students intent to modify the design prototypes from the standard one to various widths.

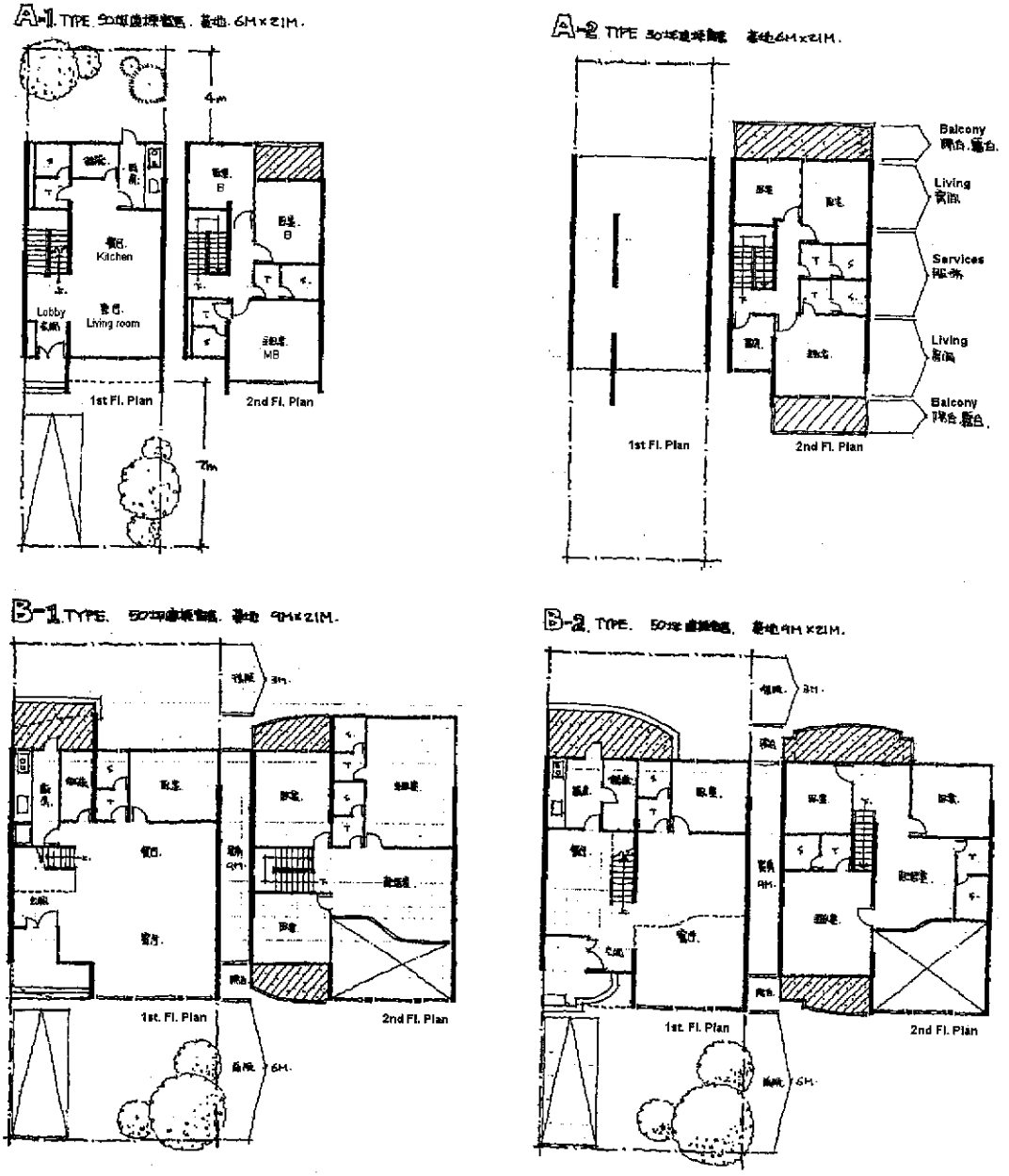

Figure-8: Two Cases for A-type and B-type units

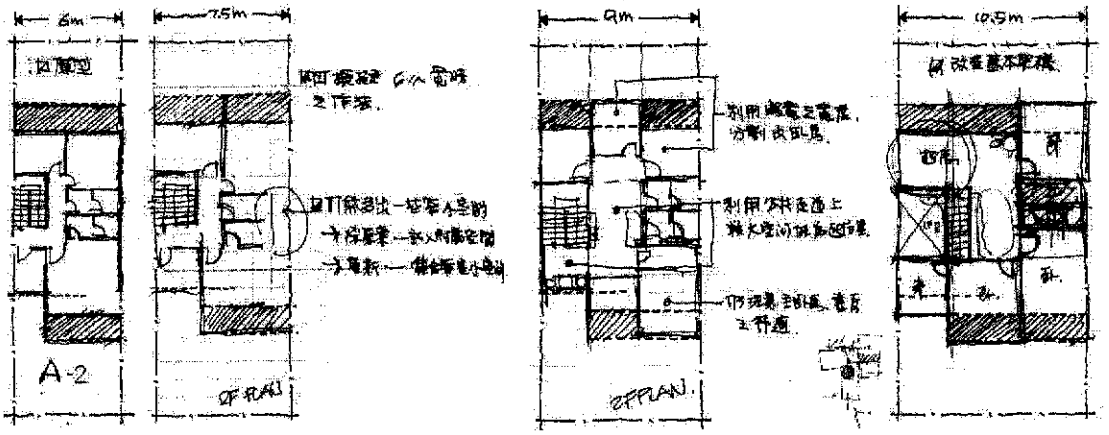

Figure-9: Student's Sketches of The A-Type Unit Plan in Various Widths

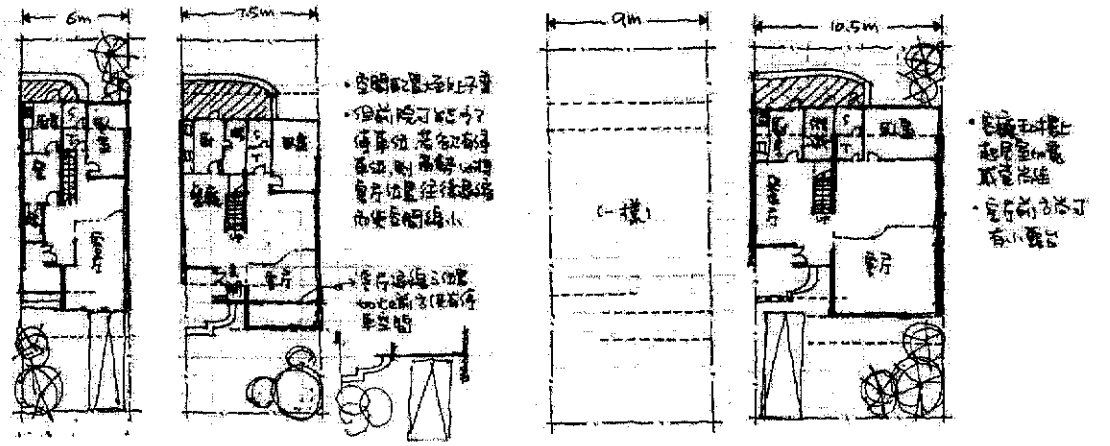

Figure-10: Student's Sketches of The B-Type Unit Plan in Various Widths

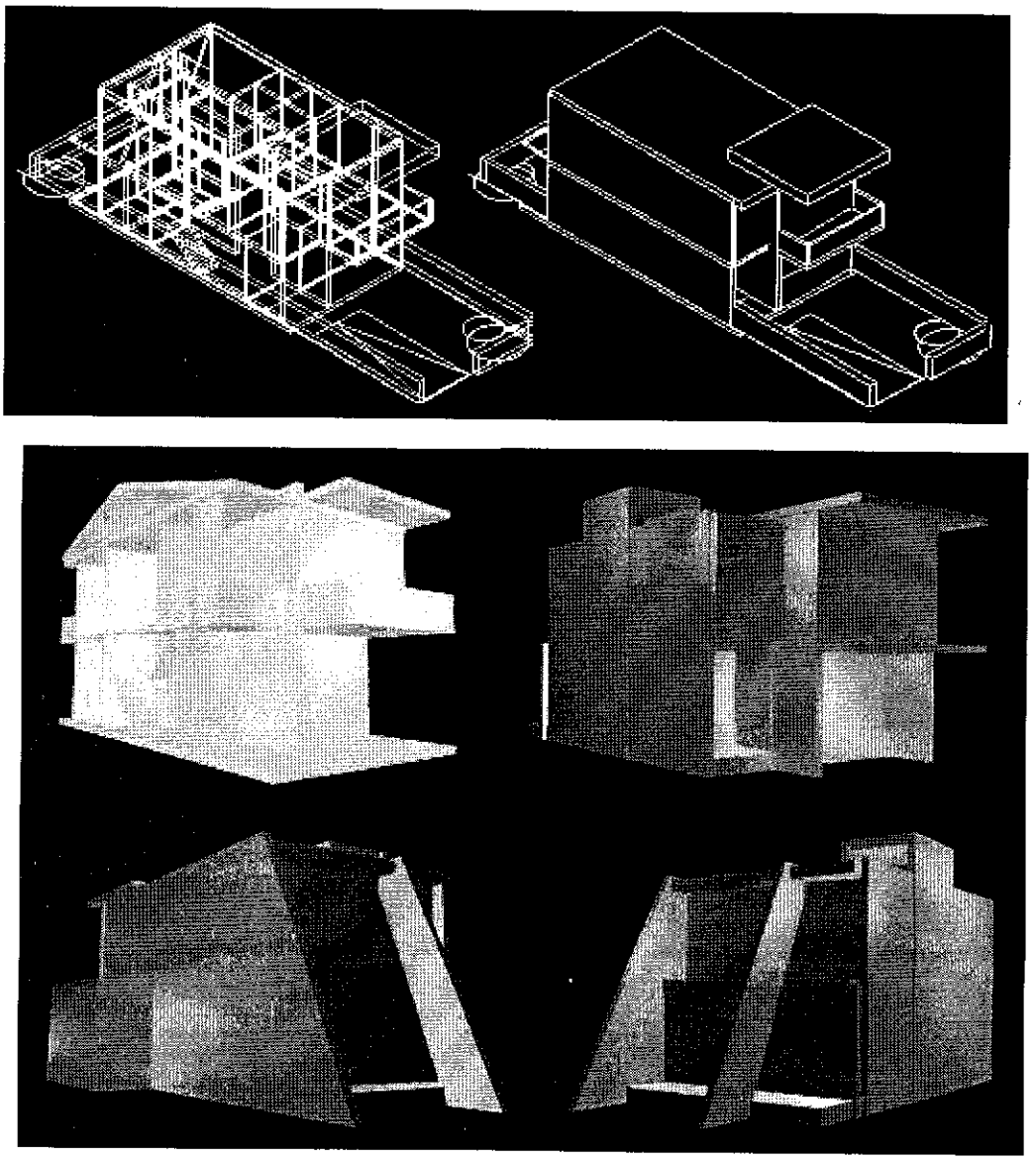

Figure-11: Massing Study

Figure-11 shows that once the basic scheme was decided, then configuration could be easily built three dimensionally, and building form could be studied. The housing unit could be studied both from inside out and outside in, such as the corner unit shown in Figure-12. The changes should also reflect the functional and environmental needs. At the final stage, each student had to demonstrate their work as an integrated work. Figure-13 and Figure-14 illustrate the final view of the row house in the northern corner and the virtual community respectively.

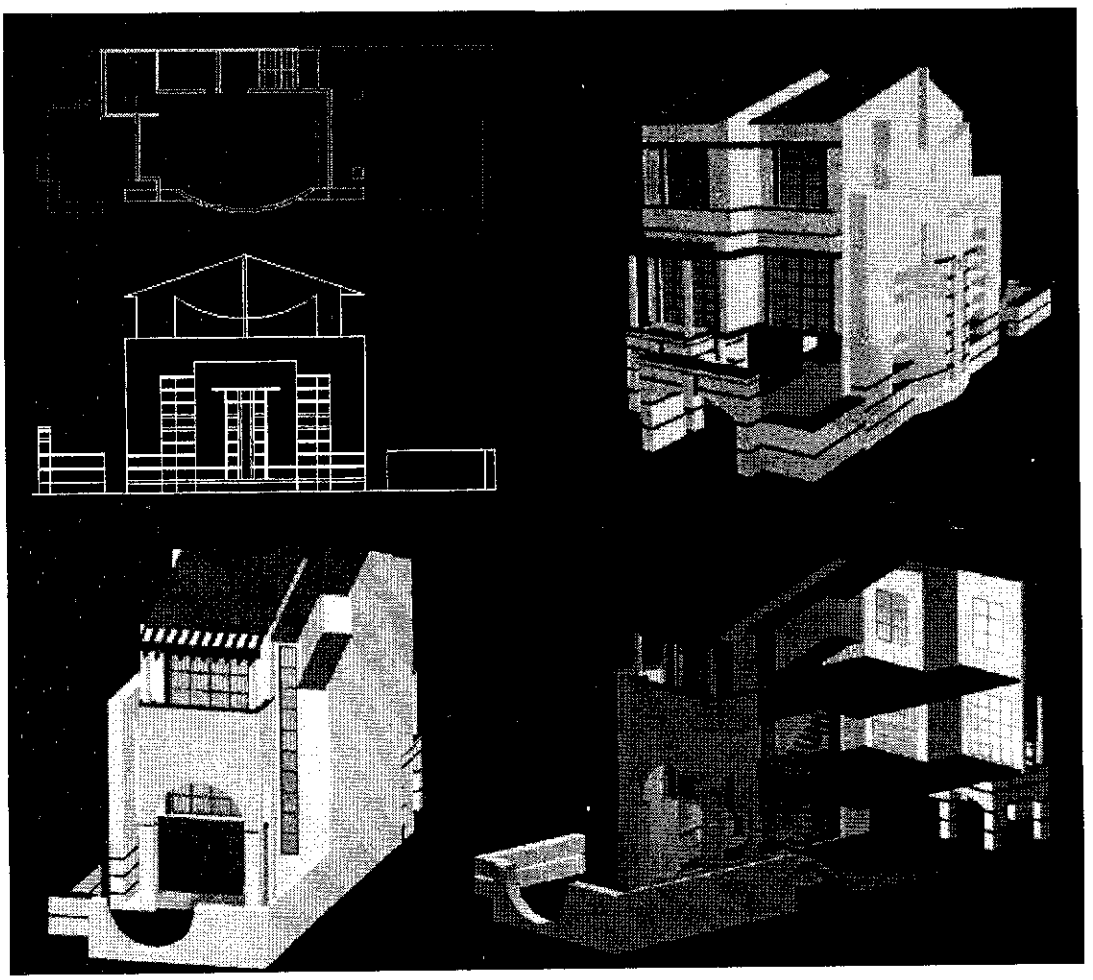

Figure-12: The Final Project of the Corner Unit

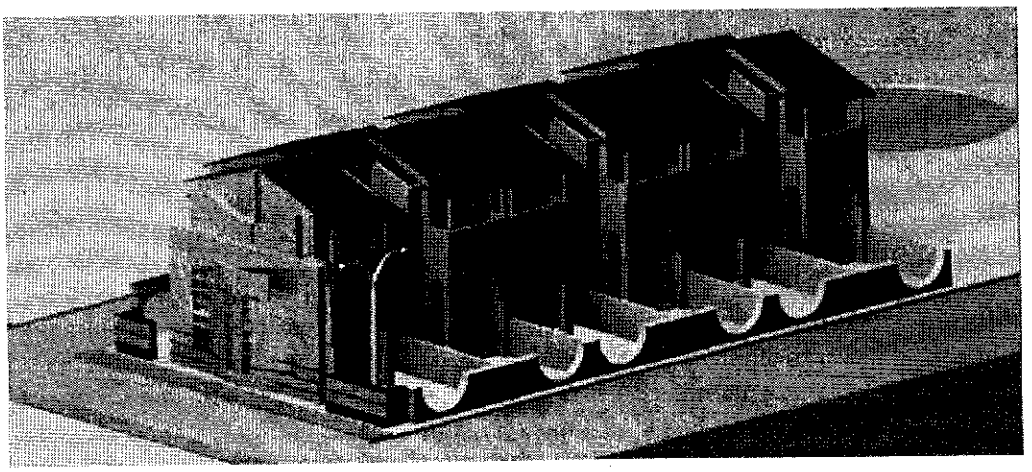

Figure-13: The Final View of the Row House in the Northern Corner

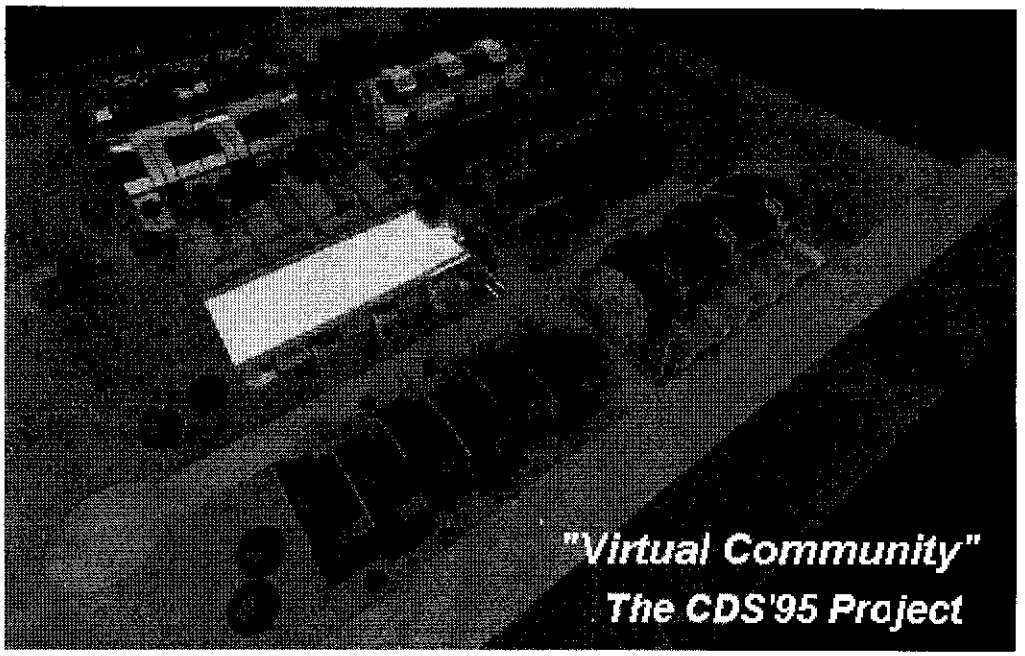

Figure-14: The Final View of the Virtual Community

5.0 THE FINDINGS

Both the teaching and research agenda are carried out in the exercises. The major findings of the above exercises include:

1. The use of a formal design approach: From design guidelines to the development of prototypes, variations and composition, the approach provides a constructive process for developing and applying design prototypes in urban housing design. This approach is particularly useful for novice designers such as the second or the third year undergraduate students.

2. The use of design prototypes: A design prototype is a conceptual schema for representing a class of a generalized grouping of elements derived from alike design cases [Gero 1990]. Design prototypes provide the basis for the start and continuation of a design. The uses of design prototypes allow designers shorten the design thinking period instead of directly using design guidelines. Design prototypes can be further developed with the supports and infill components. Designers can also use design prototypes to refine or examine the effectiveness of the design guideline. Furthermore, design development is successfully elaborated with the provision of cases. The case-based approach in architectural design seems to be feasible. However, the limitation of prototypes is clear because prototypes have to be pre-defined.

3. The use of CAD tools: The demonstration shows that CAD tools are useful, particularly in the exercise of variation and composition. Students can easily modify the prototypes and present their ideas three dimensionally. Both the free-handed sketches and CAD drawings can be used complementary.

4. The use of internet and world wide web: The net and WWW provide an accessible asynchronous host for reflections, exchanges of ideas, and remote jury. Students learned from browsing the other students' work and comments. Designs are elaborating with positive competition and collaboration. On the other hand, instructors can keep

tracking of the design process and provide the necessary advises and technical assistance.

6.0 CONCLUSIONS

The above exercises are carried out successfully because both the teaching and research agenda are implemented mostly, and the result is promising for continuous development. The above findings also provide the foundation for the future experiment and exercises. The formal design approach can be further developed as the computational design method in the CAAD studios. The use of internet in architectural design and education will be important for the students and instructors. Indeed, the networked distributed design culture is growing, but the course structure of CAAD studios on the internet will need to be well planned.

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