Journal of Civil Engineering and Architecture 18 (2024) 363-372
doi: 10.17265/1934-7359/2024.08.001

Hybrid Architecture: A Studio-Based Pedagogical Framework for Digital Architectural Design

Riccardo Balbo
IED Turin, via San Quintino 39, Torino 10121, Italy

Abstract: This article intends to bring a new perspective to the discussion of how studio-based education in architectural studies can improve its quality by embedding meta-tools as paradigmatic frameworks as a learning/teaching strategy. The newly emerging creative and collaborative digital design tools and systems led to the re-shaping and re-definition of the traditional studio-based teaching/learning processes. The shift does not only comprise of a newly gained ability of using "design toolkits", but also has substantial cognitive and pedagogical implications. The paper presents, describes and discusses the application of a new pedagogical approach through the application of a novel knowledge framework, that has been used in the teaching of DAD (Digital Architectural Design) in the context of a master's level course.

Key words: Architectural education, design pedagogy, digital architectural design.

1. Introduction

The main context in which digital tools are utilized in architectural education is the design studio. The studio environment has been incrementally refined over time by merging design knowledge and methods, traditionally introduced by the Beaux Arts and the Arts and Crafts movements, and has become one of the most complex project-based teaching schemes [1]. This complexity was described by Dutton [2] defining the studio as an "active site where students are engaged intellectually and socially, shifting between analytic, synthetic and evaluative modes of thinking in different sets of activities (drawing, conversing, model-making)." In a technology mediated design studio, one of the biggest challenges for the educator is the monitoring of the cognitive implications of the digital media adopted, to balance the underlying pedagogical agenda and the intended learning outcomes through a particular brief.

The research landscape for digital architectural design is highly focused on the affordance of the technology within a design project life-cycle, specifically on the operational and instrumental dimensions of technology development. However, the impact of digital technologies is obviously not only restricted to the achievement of complex formal varieties or the management of increasingly large datasets. Recent studies on architectural design pedagogy [3, 4] draw attention to reformulation of the core nature of design problems faced by students, such as new tectonic possibilities and emergent design methodologies. There is consistent evidence that majority of technology implementations in educational contexts are quite opportunistic and experimental rather than in accordance with any particular pedagogical models and usually quite disintegrated from the rest of the curriculum without a clear strategic or pedagogical agenda [5]. In this article, we aim to propose a new pedagogical model, through the use of a knowledge framework. More specifically, we will give an account of a novel pedagogical strategy implemented for the DAD (Digital Architectural Design) masters course at the School of the Built Environment, University of Salford, between 2008-2012. The pedagogical strategy presented is based on a framework that entails five core

Corresponding author: Riccardo Balbo, architect, research fields: urban design.

dimensions of design process from a multidisciplinary perspective: form generation, representation, rationalization, materialization, and fabrication [6]. Students have been asked to reflect on their design process through this framework and through conscious monitoring of the emergent interrelationship emerging during their design process. This framed flexibility allowed a high degree of situated design explorations within the boundaries of different design briefs. In the following sections this experience is described by presenting the context in which it was utilised (Hybrid Architecture Studio together with additional supportive, parallel modules). The details of the framework, sample students projects and a reflective evaluation will be discussed in the following sections.

1.1 Hybrid Architecture—The Studio Context

The rationale behind the "title" of the design studio—Hybrid Architecture—signifies two of the most crucial characteristics of the new digitally-mediating approaches to design: firstly, "hybrid" is an emergent condition that is born out of the combination of "different" entities and objects. And secondly, it signifies a novel, yet, temporary condition, signifying the ephemerality of the emergent condition. Emerging patterns of hybrid formation processes of languages, plants, humans are examples of this [7]. Similarly, as described by Arthur [8], technology is the result of a continuous hybridization process. In the Hybrid Architecture Studio, this concept has been widely considered and applied: at the static level, to address the meaning of design as a combination of two or more different processes; and at the dynamic level, as an "in fieri" condition of technology.

It is also important to note that "technology" had not been the only challenge in the setting up and delivery of an international and interdisciplinary masters course, with students coming from various different educational and cultural backgrounds, and with diverse personal expectations. In the specific context of M.Sc. Digital Architectural Design course, we had identified several other pedagogical and disciplinary objectives that could address the broader nature of teaching "digitally-mediated" design in such a multi-cultural and multi-disciplinary setting, such as:

- Demystifying formal stereotypes and design language misinterpretations;
- Avoiding the reduction of digital culture to the acquisition of software-specific digital skills;
- Allowing the development of both critical awareness and skills throughout the design project experience;
- Making the acquired knowledge explicit, and externalizing it through representations.
- Delivering the fundamental concepts behind computational design, and challenging the pervasive "software-centered culture".

2. Background and Rationale

One of the key aspects of the educational research carried out in Hybrid Architecture has been the definition of a teaching strategy that could direct students' experiences towards a digital design culture paradigm by following the above mentioned disciplinary objectives, but without imposing any particular formal agenda. There is a generic tendency among many students to focus primarily on gaining advanced skills in rendering/animation software, and/or acquiring the ability to generate and deal with complex forms. Despite a very high number of design software literacy among the younger generation of architecture students, a very small number actually have a clear understanding of what "the computational thinking process" entails, and the varying degrees and levels of complexity involved. The Hybrid Architecture design studio has intentionally offered the students a blank canvas to self-guide their own individual learning process, and to choose alternatives routes of specialization in this rather broad subject field. Therefore, tutors involved in the designs studio have paid special attention to "tuning into" each student's design intent and preferred approach to design. Similarly, no particular software or

technology has been imposed on the students. They have been introduced the merits and bottlenecks imposed by different digital media but in the end, they have been left free to use their preferred set of digital design tools. The limitation has been set in the methods to be employed, e.g. parametric design. However, whether the concept has been implemented in the overall design or only in the design of one of the building systems was left to the individual student to decide.

2.1 Brainware, Not Software

The current software market is defined by fast transformations, a high content of innovation and with a high degree of exposure to fashionable trends in architecture. In such a fast-changing environment, a disproportionate emphasis on "software skills" in the education of novice designers would not be a sustainable strategy. In order to stimulate a dynamic and open individual critical growth, students had been given the freedom to pick/use the software of their individual preference. The studio usually started with an introduction of a wide set of digital tools which were made available to students, to cover all the aspect and stages of the process. This has led to a kind of "shelf to laptop" approach where students had been encouraged to select, install and try tools as a sort of digital flaneurs: potentially a motivating/encouraging approach for engaging students in a process which is reminiscent of what actually happens in many design firms. The main rationale behind this approach was to encourage students to conceptually link the "choice of the tool" to the "task in hand" and to make a conscious effort to choose the right tool for the right purpose. However, this had also posed challenges for those students who were not used to taking initiatives in their formal education.

During the first two years of the program (2008-2009 and 2009-2010) a conscious decision had been taken not to deliver any software trainings. However, in the following years, both due to the pressing needs and requests from the students and to somehow level the high variations in students' skill sets, an online/virtual software training service had been employed. However, students were still expected to manage their own time and decide how to best utilize their time to engage in several trainings offered by the online/virtual training service. However, this approach had also shown some limitations and bottlenecks. This was mainly due to a lack of commonly shared language and techniques across various software tools. For example, the process of "parametric modelling" and the conceptual understanding of the term "parametric thinking" had been interpreted quite differently by the students who had been following different parametric modelling software training, or different programmatic languages. Hence, an introductory training had been adopted in the latter years of the course with a specific aim to introduce a common terminology and techniques, which could be used as a frame of reference (Rhinoceros 4.0/Grasshopper/Rhinoscript). This had also helped students to start digital modelling early on during their design process regardless of their prior experience and skills in using CAAD.

2.2 Coordination across Different Modules

Another important aspect of the Hybrid Architecture studio is its relation with the other parallel modules offered within the course. The design studio has been supported with two complementary modules: one focusing on the theory of digital design, whereas the other focused on digital design strategies and techniques. The same pedagogic structure was implemented during the second semester, with a shift of scale and focus. While the first semester focused on the development of individual design skills at the architectural scale; the second semester aimed at developing collaborative design skills at urban scale. Similarly, the design studio (The Virtual City) brief in the second semester usually focused on a group-project, usually required a novel design (or regeneration) of an urban area, with a special emphasis on the continuous interaction between the

urban and architectural scales. Both studios have been designed as laboratories of "reflective digital practitioners" where topics, positions, strategies and processes introduced in both theory and technology modules could be tested, experimented and assessed in the context of different design exercises. More importantly, the studios had been aimed to be the main arena where students could develop their own individual positions as "digital practitioners". Such an integrated approach across different modules and the design studio required a high degree of coordination and team-work across the different tutors of the course in each semester. This synchronously intertwined learning model also helped students to discuss and reflect on their design propositions (developed in the design studio) in different modules with different tutors.

3. A Framework for DAD Education

One of the key pedagogical challenges of designing this masters course was to be able to respond to the ever-changing student demands and expectations, to keep the core syllabus up-to-date with the continuously expanding knowledge content of the field and at the same time stay within the key objectives and learning outcomes of the programme. This required a novel teaching/learning strategy. The potential solution had been identified in the adoption of a general framework that could be used as a meta-tool. The framework should be able to help students in acquiring a critical awareness of the subject matter—regardless of their diverse disciplinary backgrounds and expectations; help students understand the ever-changing relationships between forms, technologies and processes; and help students reflect on their own design process and compare it with that of their peers'. The use of frameworks in teaching/learning in design is not a new phenomenon. Oxman [9] states that the use of frameworks as meta-descriptive paradigm, not bound with historic and technologic specificity, can help overcome the apparent differences introduced by styles, markets, languages and contexts. A similar approach might be found in Zevi's [10] seven principles of modern architecture invariants, grounded in the structuralist analysis approach introduced by Roland Barthes. A core principle in using and applying such frameworks in design studios is to emphasize the "design process" and provide a tool for the students to reflect on their own design process. This introduces a radical shift from the rather product-centred focus of the traditional design studio. This is also a crucial shift in the studio-based education, de-placing the value of the designs from their phenomenological aspects to their ability to create knowledge. This approach supports our core pedagogical construction of the design studio exercises as a platform to facilitate theoretical and critical reflection. And more importantly, the adopted approach would help students gain skills and understanding of radically new approaches to design without the need to erase or disown what students already know, but instead, providing them with the ability to understand the new content with relevant frames of reference and helping them contribute to the emerging cultural/intellectual landscape. The adopted framework had originally been developed by Kocaturk [6] for collaborative knowledge modelling in design studio education, but had proved to be a useful tool in design teaching/learning. The framework is based on a decomposition of 5 generic design phases, namely: Design Intent (Form Generation), Representation, Rationalization, Materialization, and Fabrication (Fig. 1).

- Form generation: specification of the formal qualities and design approach;
- Representation: visualization or other description of the design object for subsequent phases;
- Rationalization: iterative refining stage to achieve feasibility;
- Materialization: behavioural properties and aesthetic qualities of the materiality of structural system, technologies and components;
- Fabrication: selection of the fabrication processes, tools, techniques and strategies.

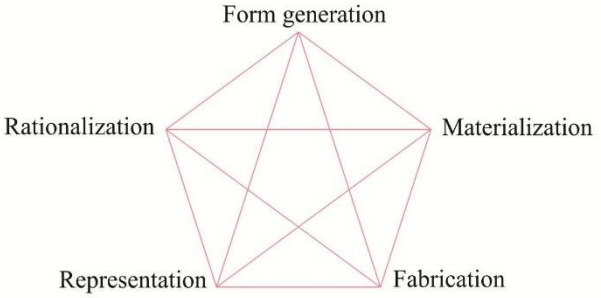

Fig. 1 The contextual framework of the knowledge elicitation/analysis, illustrating the semantic relationships across the five mentioned categories. Source: Kocaturk [6].

These are the recognized categories of various design stages relevant to both design and realization processes. The categories are characterized by the type of problems and solutions they generate during the life-cycle of a project. Each category comprises of different concepts (strategies, methods, techniques, etc.). For conventional design processes, designers could manage these iterative processes intuitively given the experience and familiarity with the standardized building components and construction methods. Nonetheless, in the domain of digital design, the emerging digital processes extend and add to the existing design knowledge with the introduction of:

- new tasks and concepts under each category;
- emerging semantic and dynamic relationships across categories.

The links created among them define the unique ways in which different designers frame the design problems and the solutions they bring to unique situations. While certain relationships are emphasized more in one project, others may become less important as the design process progresses. With each project, new relationships can be introduced, either empirically or through the introduction of new facts and relations. Thus, the links and associations created can be recognized as the strategic and situational dimensions of design knowledge, as introduced by Kocaturk [6]. While situational knowledge is necessary to recognize problems for the selection of the relevant categories, strategic knowledge refers to the conscious and tacit decisions made [11]. Following the definition of Lawson [12], it is the very interrelatedness of these concepts that is the essence of design problems rather than the isolated concepts themselves. According to Eastman et al. [13], a better understanding of the process of structuring problems allows further insight into our understanding of the design processes followed by designers. We define these problem structures as the ways in which various concepts interact in each project.

3.1 Implementing the Framework

Instead of implementing the framework in a single design brief, with a focus on a single design task, the studio tutors introduced a sequence of complimentary design exercises in one semester. Each design exercise required a reflection on the semantic relationships between different categories of the framework (Fig. 2).

The proposed method of implementation of the framework through these design exercises served to achieve the following three main goals of the design studio:

(1) To help students understand the scope and depth of each category within the context of computational/digital design practice, and compare this awareness with that of traditional approaches to design.

(2) To help students understand the emerging semantic and dynamic relationships across categories.

(3) To help students reflect on their own digital design process and to be able to compare their unique approach with that of their peers'.

The first two exercises were a combined analysis and remodelling task. Students were given a precedent analysis task in order to help them get acquainted with the design context. They were asked to analyze these precedent designs and their production processes and then to extract knowledge and model using the knowledge framework. Case study approach to learning utilizes real or imagined scenarios to teach students about their field of study. The key in this technique is that the students are challenged to learn by doing, develop analytical and decision making skills and internalize learning.

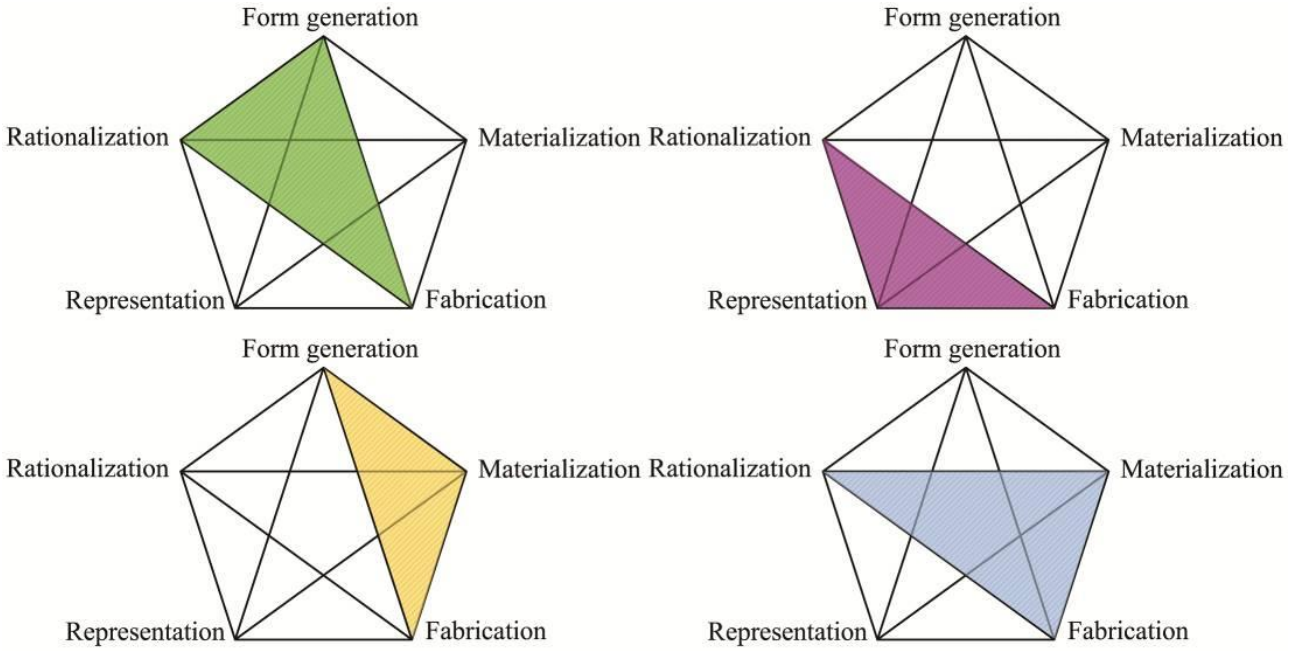

Fig. 2 The design exercises aimed at investigating the semantic relationships between different categories of the framework.

The students were asked to understand the relationship between representation-fabrication-materialization of an existing building through precedent analysis. As a second step, they were required to develop alternative methods of materialization and fabrication techniques for the same building and represent these methods through physical and digital modelling. Through these exercises, students had the chance to critically contribute to the discussion of the tectonics in digital architecture, and understand the multi-faceted relationship between form and its rationalisation process. The first two exercises specifically aimed at providing an informed awareness of the different techniques used for internal and external digital representations (both physical and digital) of designs and the precision, clarity and detailing involved in each. By describing and analyzing precedents, students have built a repertoire of concepts which characterize the digital design domain.

Fig. 3 illustrates two different interpretations of the rationalization process (by the student) of a precedent building through physical modelling. The student investigated the possible rationalization and materialization processes of a complex and highly-curvilinear architectural form (of a precedent building), and developed alternative physical representations of this investigation. The second exercise, on the other hand, focused on an investigation of alternative digital representations of the architectural form. Fig. 4 illustrates the different investigations of different digital modelling techniques for structural analysis and for the CNC prototyping of the working model (based on a precedent building). Students had also investigated the differences in the precision, abstraction and clarity needed in each digital model for different purposes and at different stages of the design process.

The third exercise was the design assignment. The assignment focused on a group design task where students have been asked to design a building product/object—through a parametric design approach—and to reflect on their design process using the knowledge framework. The initial aim was the use of the framework as a tool to critically reflect on their parametric thinking and design development process (reflection on action). Using the framework, they were required to identify the processes, tools and techniques that they have used under each category, as well as the links they have discovered between these categories throughout their

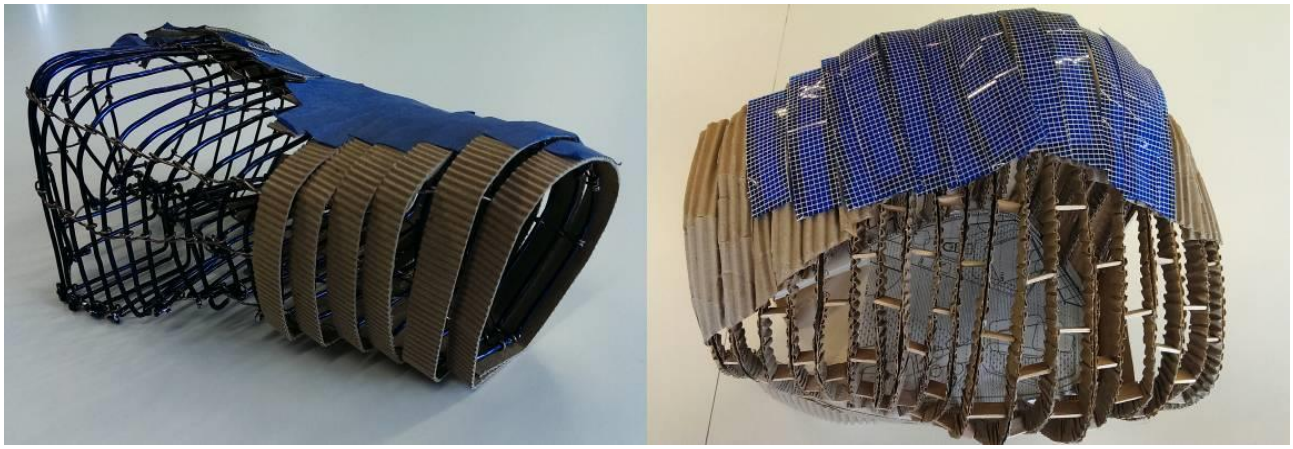

Fig. 3 Two different examples of interpretative physical model of the same building. On the right the model provides a higher understanding of the fabrication-materialization process.

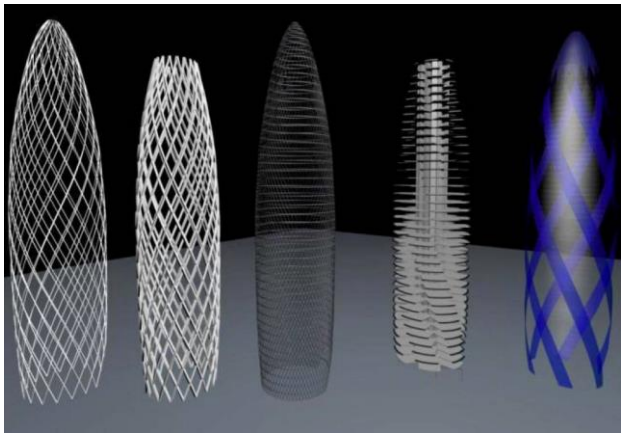

Fig. 4 Different modelling techniques representing the same building with different focus and for different prototyping technologies.

individual design process. In summary, they were required to record their design process leading to information and to track the dependencies between cross-disciplinary decisions and information in a collaborative design process. Later on, they were asked to explicate their design experiences by storing both product and process related information generated during their design process.

Fig. 5 illustrates the various investigations of the different states and representations of the design object by one particular design group. In this particular example, the students created a parametric model (using Grasshopper plug-in for Rhinoceros 4.0) where the design parameters had been set to drive the changing states of the form (both its skin and the underlying structure) and its materialization process. As an emergent phenomenon, the framework did not only serve as a design reflection tool, but also inspired students to create new links (e.g. parametric relationships) between different states of their designs (e.g. form generation linked to rationalization).

The experimental setting for all three exercises complied with the two philosophical models of experiential learning as described by Kolb [14] and Piaget [15]. Kolb's emphasis is on the experience, followed by reflection, which in turn is assimilated into a theory where new hypotheses are tested in new situations [16]. Piaget focuses on knowledge and the ability of its assimilation. This assimilation is related to the students' cognitive schemata which is influential for the acquisition and utilization of knowledge. In both workshops, although all students who took part in the design experiments were Master's level students, each student had a different level of experience and familiarity with the design context. Since the students, as novice designers, are known to have less experience in clustering of concepts, generalizations and abstractions, they have been provided assistance on these aspects. The set-up of the workshop and the design assignments were also optimized on this particular aspect by the following arrangements [6]:

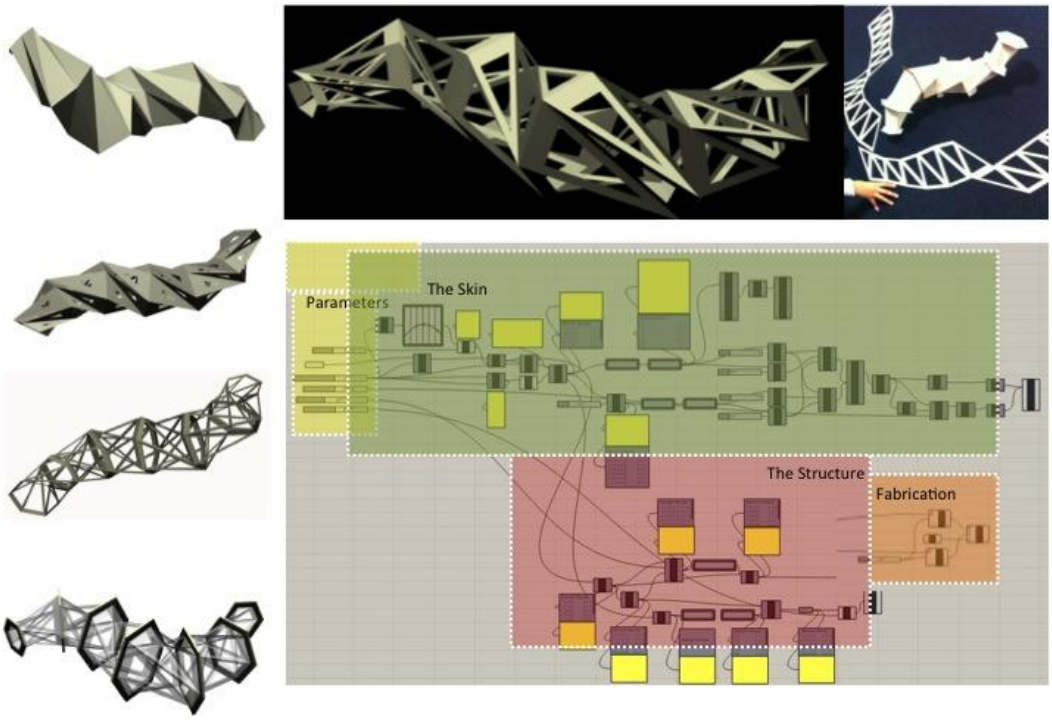

Fig. 5 Representation of the "parametric conceptualization" of the relationship between rationalization and fabrication of the design object (designed by students Kereshmeh Afsari and Shatha Abualfaraj, 2011).

• The role divisions between collaborating students intended to scale down the individual tasks to manageable quantities and help them to focus more on the aspect of exploring multiple alternatives rather than one single solution;

• As a final product they were asked to generate various conceptual solutions and compare them rather than one single solution worked out in detail;

• They were asked to generate conceptual solutions at different levels of abstraction in a collaborative setting, thus encouraging them to develop a "parallel lines of thinking" [17];

• They were asked to define their design solutions in relation to the problems they have formulated, thus encouraging them to make generalizations of the possible problem structures of the digital design domain,

The reflection ("in" and "on" action) based design exercises have been observed to increase the student performances, promote beneficial cognitive processes and consequently increase their knowledge acquisition and utilization.

4. Discussion and Conclusions

This paper has introduced both a course structure and its implementation during the M.Sc. Digital Architectural Design at the University of Salford (UK). An analytical knowledge framework has been utilized (in Hybrid Architecture digital design studio) which led to the development of a new pedagogical framework. This framework, based on five core dimensions of the design activity, has provided student flexibility and self-guided individual learning, while encouraging cross-disciplinary distributed learning across different design tools and techniques. The analytical and integrative framework proved to be useful in the sense that it gave the students the basic skills to critically compare different designs, and implement the newly acquired skills and concepts in their own design processes. Moreover, it assisted the students in providing a conceptual understanding of the digital design domain and its context specific problem structures. We have observed differences in the ways how each students applied these newly gained skills in their own projects,

and the degree to which these skills could be applied according to project characteristics. From a pedagogical point of view, the framework enabled the tutors to control the level of complexity of a series of exercises which led to a sequential development of understanding and skills in a highly specific field of expertise.

With our particular approach, the students have been given the opportunity to approach digital design as a systemic, complex and intertwined paradigm. Additionally, due to the highly interdisciplinary nature of the "knowledge categories" involved in the framework, they have been forced to think outside their disciplinary boundaries and further investigate the mutual dependencies of their cross-disciplinary decisions and actions. The representation of knowledge presented through our analytical framework also created a transferable and reusable body of knowledge, that contributed to peer-to-peer learning within the studio. Understanding the changes in the structure and the state of knowledge is the first foundation to establish specific teaching objectives in digital architecture design education. One of the objectives of the teaching method applied throughout the research is the involvement of the students in creating knowledge. This approach did not only motivate the students in their effort, but also provided them with a conceptual understanding of diverse processes and techniques involved. This approach challenges the common product-oriented approach in architectural design education where students are implicitly guided and taught with an understanding that design knowledge is actually encoded within the geometric artifacts of design [18]. Design studio should not be a medium where the students merely learn to master various digital design software, but they certainly require an understanding of the general principles that are necessary to experience, produce and analyze digital architecture with all of its complexities.

Acknowledgments

Some sections of this paper, as well as some images, are based on a previous work published at the 2nd International Conference of Structures and Architecture [19]. Author would like to acknowledge the work and contribution of all the students of the M.Sc. Digital Architectural Design course at Salford University between 2008-2012.

References

[1] Cunningham, A. 2005. "Notes on Education and Research around Architecture." *Journal of Architecture* 10 (4): 415-41.

[2] Dutton, T. A. 1987. "Design and Studio Pedagogy." *Journal of Architectural Education* 41 (1): 16-25.

[3] Oxman, R. 2008. "Digital Architecture as a Challenge for Design Pedagogy: Theory, Knowledge, Models and Medium." *Design Studies* 29 (2): 99-120.

[4] Allen, S. 2012. "The Future That Is Now." In *Architecture School: Three Centuries of Educating Architects in North America*, edited by J. Ockman and R. Williamson. Cambridge: The MIT Press, pp. 204-29.

[5] Kocaturk, T., and Kiviniemi, A. 2013. "Challenges of Integrating BIM in Architectural Education." In *Proceedings of the 31st eCAADe Conference* (Vol. 2). Brussels: eCAADe, pp. 465-73.

[6] Kocaturk, T. 2006. "Modelling Collaborative Knowledge in Digital Free-Form Design." PhD thesis, Delft University of Technology.

[7] de Landa, M. 2000. *A Thousand Years of Non-linear History*. Cambridge: The MIT Press.

[8] Arthur, W. B. 2009. *The Nature of Technology: What It Is and How It Evolves.* London: Penguin Books.

[9] Oxman, R. 2005. "Theory and Design in the First Digital Age." *Design Studies* 27 (3): 229-65.

[10] Zevi, B. 1994. *The Modern Language of Architecture.* Cambridge: Da Capo Press.

[11] Jong, T. D., and Ferguson-Hessler, M. G. M. 1986. "Cognitive Structures of Good and Poor Novice Problem Solvers in Physics." *Journal of Educational Psychology* 78 (2): 279-88.

[12] Lawson, B. 1980. *How Designers Think.* London: Routledge.

[13] Eastman, C. M., McCracken, W. M., and Newstetter, W. C. 2001. *Design Knowing and Learning: Cognition in Design Education.* Amsterdam: Elsevier.

[14] Kolb, D. A. 1984. *Experiential Learning: Experience as the Source of Learning and Development.* Englewood Cliffs, NJ: Prentice-Hall.

[15] Piaget, J. 1971. *Psychology and Epistemology.* New York: Grossman.

[16] Kocaturk, T., and Veltkamp, M. 2005. "Interdisciplinary Knowledge Modeling for Free-Form Design—An Educational Experiment." In *Computer Aided Architectural Design Futures 2005*. Dordrecht: Springer, pp. 465-74.

[17] Lawson, B. 1997. *How Designers Think: The Design Process Demystified* (3rd ed.). Oxford: Architectural Press.

[18] Mitchell, W. J. 1990. *The Logic of Architecture: Design, Computation, and Cognition.* Cambridge: MIT Press.

[19] Balbo, R., Kocaturk, T., and Veliz, A. 2013. "Hybrid Architecture: Coupling Structural Understanding and Architectural Education." In *Proceedings of the 2nd International Conference in Architecture and Structures*, Guimar ães, Portugal, July 2013.