Understanding the Relationship between Construction Courses and Design in Architectural Education

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Nowadays, architecture education concentrates mostly on form, space, and general subjects as well as considerations of function, and art theories about design. Least attentions are on technical matters, construction courses, which cannot stand separate from the design process. This lack of synchronization between architectural design and construction courses have resulted in the idea that only design product is paramount in architectural education. However, the nature of construction courses is mostly technical and mechanical, which make it challenging for students to understand and truncate their passion for furtherance on the subject. This paper aims to examine the problems related to the learning and understanding of construction technology and its connection with the architectural design. And also to identify the primary learning necessities essential for achieving a better learning performance in construction courses, by analyzing the curriculum of construction courses of Faculty of Architecture, EMU (Eastern Mediterranean University) as case studies, and related information in the current literature written between (1993-2015) whose discourses focus on: Teaching construction technology, Bridging the gap between Theory and Practice, Education and practice of building and Evaluating Constructive Thought of Master Builder.

Keywords: Architecture education, Design-build, Virtual reality, Construction technology.

I. INTRODUCTION

The core role of architectural education is to prepare graduates for practice [1]. What practice needs, besides a professional design skill, is an adequate knowledge of building science to show how they stand up and constructed. For this reason, apart from all other targets which the education might have, it should have an indispensable relationship between design studio and construction courses. Because the overall understanding will exist about architecture projects when both design studio courses and technical courses have the same weight of attention. If we come back to the 20th century, we will see the trajectory of the most prominent schools of architecture which had worked towards educating architects with a diversity of knowledge from different disciplines. This school was Bauhaus, led by Walter Gropius in 1919-1920s. “The Bauhaus was originally organized so that ‘all the arts and crafts are brought together in the production of architecture” [2]. The ideology of this school left a lasting practice in the schools of architectures globally via compulsory course known as Fundamentals of Design. In 1925 the school moved from Weimar City to Dessau where it confronted Nazi's government criticisms under the directorship of Hannes Meyer and later by Mies Van der Rohe but was damaged by WWII in 1933 [1].

Nowadays, architects step far and far away from building production notions [3]. Tschumi justifies his speeches by mentioning these three points:

- First Disconnection: Carpenters and masons always build, not architects.
- Second Disconnection: The industry addresses methods of construction, not architects.
- Third Disconnection: Construction drawings are not prepared by ‘Design’ architects, Job architects do it instead [3].

Unfortunately, architecture education presently delivers construction knowledge separately in the design studio. It created a myopic perception of the graduates of architecture by seeing construction issues away from their profession. Furthermore, reduces their construction knowledge which is more related to the practical life of the market.

II. ARCHITECTURAL EDUCATION

The history of the relationship between design and construction dates back to the medieval times. As architects had accurate knowledge about both design and construction, and they were involved in the construction process [4]. Also, Ecole Royales de Beaux Arts which founded in 1648 as an academic school, its curricular contained history and theory of architecture, perspective and mathematics, and construction to mention but a few, theory courses were taught in classrooms and design in the ateliers [2, 5]. Second revolutionary school in the history of architecture was Bauhaus in 1919 in Germany, which after that sparked all over the world via its lines of continental movement and academic mentoring situations of its frontiers like Gropius and Mies Van der Rohe to America.

Revised Manuscript Received on September 25, 2019.
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The pedagogy in Bauhaus was a kind of balance between mental and manual skills. As the instructions of the school, there were two types, formal and practical education. The formal teaching divided into three subjects: Design (composition, colour, and volume studies), representation (model-making, draftsmanship, construction, and plane geometry studies), and aspect (nature and materials studies), the practical instruction was all about dealing with many different kinds of materials, such as wood, clay, stone, textiles, and glass [6, 7]. The lessons from Bauhaus is, there was a holistic process regarding all interrelated subjects of architecture and giving the weight to all of them including construction in a balanced manner with the design. For that, students of architecture had the chance to practice what they would learn in theory and experience the process of making by hand.

More recently, Uluoğlu [8] referred to four main courses which architecture education consists of, they are: "Fundamental courses are theoretical courses, the technology-based courses include construction, structure, material courses, and expression-based courses embody technical drawing courses and Design studio courses"[9]. The scenario also suggests that construction-related courses are essential in all architecture schools. However, the manner by which the integration of the design studios organized poses a disconnection and a negative impact on the education process than other courses that contribute to the design thinking. Because the disconnect from academia to practice from design to construction is carrying the Architecture profession out to sea: The argument between academicians, practice and the multidisciplinary of architecture, construction, fabrication, and design reality fostering the connections are frustrating the mentality that led to beautiful architecture [10].

Tectonics in architecture can be defined as "the science or art of construction, both about use and artistic design" [11]. So considering building construction as a design issue will be achieved in the way of combining the aspects of tectonic design into design studio [1]. The more tectonic principles are taught in the design studio, the more the awareness and participation of students in construction schemes.

Endeavors towards better construction education

The ideas of teaching and working it out relate to showcase the reality of abstractive conceptualization of architects. Progressively, providing the qualities that enabling viewers, craftsmen, and users to comprehend the designer's thought through the project development.

A. Design-build

Gaber [12] in his article about how to 'make' in architecture for the newest opened school of architecture after 40 years in the area, the architecture school at Laurentian University in Canada. He insists on the necessity of design-build (learning by making) in the early stages of studying architecture. What Gaber called for is such a principle, which students have to obey during design thinking. Students are required to make real size construction for their designs, with the considerations for historical, cultural, specific needs, budget, time, commercialization and available construction materials of the context selected for their design. First; students make the models in 1:10 scale, for the appraisal stage and then constructing in 1:1 scale with the available construction materials.

B. BIM Programs

Today much software will be applied with design to boost the construction knowledge. Especially, the BIM (Building Information Modelling) based programs which they have intelligence. These programs have the potential of offering a wide range of expertise in construction details, realistic renderings, time management schedules, and quantity calculations. Also, some of them can test the structural members put in the design, such as ideCAD which is BIM-based software. Alakavuk [9] proposes ideCAD to be used in the design studio for 'Integral Design Studio III' in architecture department, Yasar University in Turkey. She supervised this class which had opened in 2013, and she required the students to consider earthquakes during design for residential units, by using ideCAD. Students provided structural units and then tested by ideCAD, which the program let them observe what they have done to be right or wrong. Students could examine the logic of the dimensions of structural members, as well as the ratio of materials (such as steel ratio in a column), technical explanations of the construction members. Each author profile along with photo (min 100 word) has been included in the final paper.

C. Laboratories

Elawady and Tolba [13] describe the three sorts of laboratories which are: Hands-on labs, simulated labs, and Remote Labs. The three Labs are explained thus:

(1) Hands-on Labs are Labs, where every knowledge or investigations are obtained via physically set up process, and real-life experiments are done.

(2) Simulated Labs referred to computer-based operations, which are imitating of the real-life ones, but they are simulations of them, but with lower costs and time.

(3) Remote Labs are similar to the hands-on Labs regarding the necessity of having space and real Labs. The difference is having the distance between the experimenter and the experiment, which controls are mediated by computers.

These three types of Labs can be separately or connectively used in the process of teaching and learning, which the University of Colorado had experimented a case how to combine them. Ma and Nickerson [14] and Elawady and Tolba [13], compared these three laboratories, and they concluded that hands-on Labs are more effective than other kinds of Labs.

Hands-on Laboratory types: Meijo University in Japan has opened a specific department under the department of architecture which is the department of laboratories. This department consists of five different laboratories which are:

• Design and planning laboratories: this branch pays attention to a general theme of human lives. Specialists are working in this laboratory focus on human behaviour laws, social trends, building ideal architectural spaces and building processes.

• Environmental laboratory: the area of attention of this laboratory is mainly researching, predicting and assessing noise at the urban environment level. Energy consumption issues from heating, cooling, and ventilation are handled. Another area of interest in this laboratory is a kind of assessment for the indoor-outdoor sound control by researching on the acoustic materials and methods and observing both physical and psychological outcomes. Green buildings and the heat performance are studying, with considering the effectiveness of solar energy in buildings.

• Structural laboratory: the main purpose of this laboratory is learning about safety in buildings to be constructed. Structural design is addressed through keeping the balance between rationality and aesthetics which is creating a balance between function and form at the same time. The following points are addressed:

(1) Developing technics of structural design regarding earthquake resistive designs. Also diagnosing the resistance of the historical buildings against earthquakes then researching about them.

(2) Evolving the structural analysis software.

(3) Assessment of different kinds of structural methods such as steel frame structures, reinforced concrete, wood and so on.

(4) There is a volunteer activity towards manufacturing earthquake-proof furniture to find solutions for the areas vulnerable to earthquakes.

• Materials and Construction Laboratory: Construction methods of buildings and material properties are being researched in this laboratory, and more precisely the focuses on:

(1) Researching on the historical buildings to diagnose the bearing strength by using technology.

(2) Failure in concrete is another field of research, as well as doing inspections of the reinforced concrete especially non-destructive methods of inspection.

(3) Conducting researches on environmentally friendly concrete

(4) Researching on the crack issues in concrete and controlling them

(5) Document preparation related to making documents related to building materials and construction

(6) Research on the flow behavior of fresh concrete.

• History and Design Laboratory: The main duty of this laboratory is primarily learning from the history of the previous architectural projects. Regarding restoration of the techniques and stone framing used in the past. It incorporates research on the history of design especially from Japanese and Asian. Renovation techniques are also researching for cultural heritage, as well as thoughts and criticism in architecture is dealing with [15].

D. Summer Practice

Summer practices are common in the curriculum of some architectural departments around the world, adopting different approaches over times but with a common goal. In some universities, this summer practice has the potential in raising the level of the awareness of architecture students, concerning construction knowledge, which the program arranges aiming to visit construction sites where construction might be on-going. Students will explore the opportunity to see and observe construction process and actual building construction components. Besides, the summer practice is required as a part of fulfilment for graduation. Others require the students to attend the summer holiday in an architectural design office whether in official or private places.

The University of Sulaimani in Iraq has the above program for the students of architecture in the third year, where the author has graduated. Students are free to select the place of the design office, as everyone chooses a place where preferred by him/her by considering the distance from the student's home, quality of the place,…etc., while the site visits are compulsory for all the students to be together with an instructor. Especially with an instructor who has a background in construction and site experience. After finishing every visit, students are required to write their report for what they learned and observed.

The summer practice is different from country to country; for instance, in the University of Washington, there is 'ARCH 100 architectural summer practice' which is an introductory course. This course has opened for the architecture undergraduate students, and college graduates who desire to make architecture as a career and a field of study. The program of the course is stated below:

The course is consisting of a design studio that meets three afternoons a week and is complemented by morning lectures, workshops, and field trips. Each studio of 12-15 students is taught by an instructor and a graduate student assistant who guide the students through a series of 2D and 3D skill-building exercises and building design projects. Studios are central to a design education, where students learn to work collaboratively and independently and are supported by the critiques from design jurors, studio instructors, and external critics. The seminar presentations handled by faculty members, and the local design community will open up discourse on the history, theory, design methods and architectural practice. While the field trips to sites of significant buildings and public spaces on campus and Seattle will help build confidence on the stuff taught at the studio [16].

Also in Eastern Mediterranean University in Cyprus and at the fifth semester the course 'ARCH 290' provided to enhance practice for construction knowledge of the students of architecture. The period of the course is 25 days, and the students are required to have their daily reports on sites, documenting and the department's standard training report book should be filled up and signed by the site's manager of the construction project [17]. In a similar mode, in the Cross River University of Technology, Nigeria where one of the authors completed undergraduate studies and presently lectures, the course 'ARC 4201 SIWES (Supervised Industrial Work Experience Scheme)' is introduced at the fourth year of the undergraduate program as a 6 credit units and spans through the entire second semester. The students have the same liberty to choose as discuss previously in the case of the 'University of Sulaimani'. However, they are graded as follows:

- Industry – Based Supervisor's assessment = 60%
- CRUTECH Supervisor's assessment = 20%
- Assessment of Student's Project Report (Log book) by seminar = 20% (CRUTECH-DA, 2016).

E. Virtual Reality

It can be defined as "…an emergent computer technology for full 3D-simulations, which have a natural application in the architectural work, do that activity involves the complete definition of buildings before its construction" [18]. Possibility from virtual reality to provide a (1:1) full-scale space where students can enter and experience that space, gives them realism to their senses. These virtual environments are vibrant atmospheres where students can get 'sense of presence' [19].

To derive that appreciation using these advanced visualization outfits, let the students' better understanding of plans and construction projects when applied to designs. The reading and feeling of a given space are changing now because of the influences from the development of technology leading to the production of an improved graphical interface between human and computer. Furthermore, provides a close sense of being of the real-life situation in context. And that is a privilege which is now possible to place our students in a macro-space, delineated with visual displays that permit them to feel and experiment with 3D, a full-scale virtual model of a construction project [19]. What significant in virtual reality is its capacity to substitute for a hard effort of experiencing outside, but it has to focus on the train "our students and professionals how to design in digital space without losing sight of gravity, structure, assembly processes or materiality" [10]. From that sense, virtual reality would have various fields to be used, even in architecture education; it can have a great role in different stages and many places.

Alvarado and Maver [18] state that Virtual Reality Technology could be used from fundamental courses until advanced subjects, in the diverse lines of architectural education:

- History and theory; in the modelling and review of historical cases and schematic concepts.
- Technical courses; in the modelling and behaviour of structures, revision of constructive details, representation of building services and performance, etc.
- Design Studios; in the modelling of students' proposals, review of examples of contemporary architecture, etc. [18]

F. Virtual Laboratories

Nowadays due to the rapid change of technological developments World Wide Web channel has become indispensable in education field like other life fields. For that, the notion of virtual laboratories now has become common in some learning and teaching organizations. In a way that virtual Labs are used as a substitute for the real or hands-on laboratories. Virtual Labs are based on Webs, Computer Simulations, Multimedia Technologies and Mathematical Models. It is slightly safer, lower cost, higher efficiency, and better availability than hands-on Labs. And the resources can be shared easily. Also considers as one of the future trends to be used in future distance education [20].

Following the necessity of having in Virtual Web Labs, Kang, Wang [21] and Ma, Yang [22] proposed the following three points which are:

Generation of the experiment scheme: The experiment software should provide an excellent human-machine interface; give the convenience of manual operation; and automatically generate suitable experiment schemes, with parameters supplied by the user.

Visual window support: The experiment software should provide visual support for the whole process, including the generation of the experiment scheme, network operation, and experiment data analysis.

Open system structure: A means whereby users can easily extend software, update modules or add new functions. A Web-based Virtual Laboratory for distance education [20].

The Ministry of Human Resource Development (MHRD) of the Indian government has organized a Virtual Laboratory Web between 12 universities in the country which they have the opportunity to use the system of the Virtual Labs and share the resources among each other. To minimize the cost of the Lab Instruments and also offer the students and researchers to use up to date information in the different disciplines and architecture profession also included. The (MHRD) team has declared the primary objectives of the Virtual Labs as below: To provide remote-access to Labs in various disciplines of Science and Engineering. These Virtual Labs would cater for students at the undergraduate level, postgraduate level as well as to research scholars. To enthuse students to conduct experiments by arousing their curiosity. The procedures will assist them in learning basic and advanced concepts through remote experimentation. To provide a complete Learning Management System around the Virtual Labs where the students can avail the various tools for learning, including additional web-resources, video-lectures, animated demonstrations, and self-evaluation [23].

III. Architecture Education at Eastern Mediterranean University (EMU)

The department of architecture in EMU first opened as a department under the faculty of engineering in 1991. Later became a faculty in 1997 with two departments, department of architecture and department of interior architecture. It had an industrial department for several years, but then it was closed. Now, except undergraduate program, it has graduate programs as thesis and non-thesis master programs in architecture, interior architecture and urban planning. Also, it has the Doctoral program in architecture [24]. Undergraduate program from each of architecture and Interior architecture department mainly consists of 4 years full-time studying. Basic design studio (FARC 101) is being given from the first semester, which focuses on design principles, visual vocabulary creation, 2D and 3D exercises, and enhancing students' manual and mental capabilities throughout the course [25].

Construction courses

Students are supplied construction knowledge from the third semester of studying, before that they do not have any courses about construction and structural systems.

Third Semester: The third semester allocates in architecture department, two construction courses are provided which are 'Introduction to the tectonics of structural systems (ARCH 235)' and 'Architectural construction and materials-l (ARCH 243)'. The courses details are:

• ARCH 235: This course provides information about the definition of structure and structural systems in architecture, methods of construction, equilibrium and gravity analysis, aesthetic and related to structure, economy understanding, history of structures and philosophy behind some structures. The core goal of this course is "…to provide students information about the new developments in masonry structures with the help of case studies" [26].

• ARCH 243: The aim of this course focuses on different components of a building, such as building foundations, walls, roofs, floors, columns, and beams. In the long-term, an adequate knowledge on how to transfer a project on a piece of paper to a physical stand-up building is achieved. Also, the course focuses on structural systems and cladding systems. Furthermore, the course has some activities as the design studio, model making and trying to relate it to the theoretical part [27].

The class activity for ARCH 243 course embed the under the listed method of learning and teaching:

• All students are required to attend the course with cardboard dimensioned as A3/A2 size and the complete set of drawing instruments.

• All drawings should be done with pencil. Strictly no CAD drawings or tracing paper will be accepted.

• After the lectures, a two hours studio work will follow and assignments will be finished during these hours.

• Assignments will carefully be kept in a proper file.

• Those files will be submitted whenever asked by the tutors for grading. Grading of records will be considered during the exams with high importance.

• As part of the course discipline, the students failing to do the assignments will not be allowed to the subsequent classes or to sit for the exams [27].

Fourth Semester: In the fourth-semester 'Tectonics of flexural structures ARCH 236' and 'Architectural construction and materials II ARCH 244' are provided as construction and structural courses. These courses are independent courses as the previous construction courses in the third semester, by means that they are not a part of architectural design studio courses. The outline of each course is being illustrated below:

• ARCH 236: The duration of this course is 3 hours a week. The course emphasizes the relationship between methods of construction, form and structural behaviours with tectonics of flexural structure by studying the existing case studies. Students are expected to collect the knowledge on various construction methods, structure types, trusses, walls, slabs, non-bearing surfaces, suspended surfaces, walls, design responses to earthquakes, and structure of high-rise buildings. Students are required to present what they might get in the existing case studied related to the course [28].

• ARCH 244: The primary aim of this course "is to provide students with the knowledge and skills required for wide span roof structures (folded plate, space frame, membranes, dome, truss systems, etc.), stairs, windows, doors with their detailing. All kinds of possible construction methods with their special finishing details will be dealt" [29].

Fifth semester: 'Tectonics of form resistant structures ARCH 337' and 'Architecture construction and materials III ARCH 347' are studying in the architecture department of EMU as construction courses in which:

• ARCH 337: the focus of this course is on the relation between structural behaviour, form, methods of construction, and tectonics are studied for form resistant structures, and these subjects are covered with the help of successful case studies. The relation between internal forces, form, and tectonics is discussed. Strength and deformation of members in compression and tension, and problems of buckling and wind instability are studied on existing examples, and about the effect of solutions to the tectonics of the building. Internal forces in form resistant structures are analysed with the help of physical models and comparative analysis of existing structures. Standards and regulations on their effects on the tectonics of architecture [30].

• ARCH 347: in this construction course the knowledge about prefabricated and industrialized building techniques are taught, such as modular systems in construction frameworks, skeleton, and panels. For better understanding, some existing buildings are taken and studied in detail [17].

Seventh semester: This semester is the last one which is provided a construction related course, that is 'Economic and managerial issues in architecture (ARCH 449). The aim and the description of the course are presented as:

• ARCH 449: The course highlights "the fundamental ideas of the Basic concept and definitions for construction management, Principles of engineering economy, benefit-cost analysis Break-even cost analysis. As well as Parts and Stages of construction projects, Engineering site organization, Construction contracts and their documents. Types of specifications, Bill of quantities, Project planning techniques, Bar chart network analysis arrow diagram" [31].

IV. DISCUSSION

All the construction related courses that are provided in the departments of architecture in EMU, to the third semester and the seventh semester, have the vital role in construction education. They cover different areas and subjects of the construction issues.

However, the students have not enough motivation to use the obtained knowledge from these construction courses into their design projects. Implying that the students have little enthusiastic toward attending these courses. For that, several students were informally interviewed by the authors and asked about this issue. Most of them did not hide their apathetic, and they described having these courses as wasting of time. The problem also noticed by some instructors of these construction courses, and they thought that it is related to some factors as:

(1) The construction courses are not a part of the architectural design studio, as they are two different courses.

(2) Design instructors have not enough care about construction details during the design process requirements because the architectural design instructors and construction instructors are not the same people in most of the times.

(3) Lack of construction knowledge of some of the architectural design instructors.

(4) Having no hands-on, simulated and virtual construction laboratories in the department.

(5) Traditional teaching method in the construction courses which is the teacher-centred method, so the students might not be interested in the mostly theoretical classes. However, most of the construction courses have a practical part and analysing case studies.

(6) Summer practice period is too short, which is 25 days, and students will not benefit from these construction site visits correctly.

(7) Some of the students especially females are not very interested in construction matters, as they perceive their future career as an architect office designer, due to their misunderstanding that they need construction knowledge even as an office architect during their designs.

V. CONCLUSION

Construction and architecture design are not two different fields; they complete each other in a successful design project. In this sense, construction knowledge to be fully digested by students, the construction courses should be studied with architectural design as a part of the architectural design studio. Moreover, laboratories have the crucial role in enhancing learning, which offers the chance to students to perceive structural systems, construction details, experimenting materials, the historical background of the building structures, environmental considerations, and so on. Each type of Labs has its potential whether it is hands-on, simulated or remote Labs, which strengthen students' imagination during design projects. Likewise, the proper architectural education completes with focusing on what theoretical courses may offer, combining with real-life examples. The consensus of both achieves high outcome via construction site visits during specific courses and programs such as summer practices and SIWES. Additionally, nowadays the development of technology has high potentials to be used in a straightforward way at affordable cost and time but garnishes the process with an excellent performance. So virtual realities, holograms, and other products of the new technology pave fulfilled means in the scope of architecture education and especially in construction subjects.

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