STRUCTURAL AND TECHNOLOGICAL PRINCIPLES IN ARCHITECTURE CURRICULUM OF EASTERN MEDITERRANEAN UNIVERSITY IN NORTHERN CYPRUS

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ABSTRACT

Architecture pedagogy has various aspects and requirements. To achieve a successful architectural teaching system there is a need for giving sufficient attention to structural stability and technical issues of buildings from one hand and noticing aesthetical concerns of architecture from the other hand. Curricula of architecture schools play a critical role in this regard. The ability of integrating technical and structural aspects of building design into other design disciplines can be given to students by appropriate considerations within the architecture curricula. This survey indicates and highlights the necessary basic requirements of structural thoughts for every architecture curriculum and architecture curriculum of Eastern Mediterranean University (EMU) has been specifically focused; it sefficiency in terms of teaching of structural principles has been examined through some questionnaires and interviews. Accordingly, some comparisons with the existing literatures and also curricula of well-known universities from around the world have been done; consequently, some suggestions are made to increase the efficiency of EMU curriculum in terms of teaching of structural concepts. In fact, the research is a contribution towards updating the architecture curriculum of EMU according to the latest structural and technological requirement softhe contemporary architectural education.

Key Words: architectural education, curriculum, structure, construction

1. INTRODUCTION

Architectural design process is always in concern with two major aspects; from one hand architects are to solve aesthetical issues and on the other hand, they should deliver structural stability and technical requirements of design. To achieve a successful design project by no means these two aspects can be separated from each other, they require to be integrated and inspiring each other. From the point of view of contemporary architect Renzo Piano, separation between shape, function,

structure, technology, technical knowledge and science can be hardly distinguished; between art and science there can be no obstacle; they address the same language and require the same energy (Torpiano2009).
It is the responsibility of architectural education systems to train architects with the ability of integrating building structures with aesthetical and other design features. Thronberg (2006) emphasizes the role of architecture education on creation of the desired built environment. As he states, our built environment has not the qualities that we expect and education is a brilliant way of improving our thoughts for changes in the right direction.
Study and investigation of the existing curricula can be a helpful attitude toward sattaining the mentioned goals. Study of one curriculum and highlighting its specifications in relation to structural principles of design will lead us towards understanding the potential challenges of the current architectural education. Therefore, bachelor architecture curriculum of Eastern Mediterranean University (EMU) in northern Cyprus is considered as a case study in this research.
At first, viewpoints of students are evaluated by means of questionnaires and secondly, instructors' remarks are gained through some interviews. Finally, comparison of comments from EMU members with some curricula from some universities around the world and also some existing statements of literature about structural principles in architectural design is provided. The comparisons are done based on the quality and quantity of the taught structural principles of the discussed curricula. The final results of all of these investigations, evaluations and comparisons are the proposition of some requirements for the architecture curriculum of EMU to insure the implementation of necessary structural principles within the curriculum.

2. STRUCTURAL AND TECHNOLOGICAL PRINCIPLES WITHIN SOME CURRENT ARCHITECTURE CURRICULA ANDEXISTING LITERATURE

According to the existing documents and data, throughout history architectural design has been always dealing with structural design. Even architecture and structural engineering had been considered as the same profession until industrial revolution when the divide between the two professions initiated. From the ancient time Egyptian architect and mathematician Imhotep, who is known as the first engineer in history is supposed as the architect of the Step Pyramids of Djoser (Humbert2003). In Gothic architecture, structural form is used to create particular qualities in spaces and structural elements such as buttresses and rib vaulting express special aesthetic values (Torpiano 2009). In contemporary architecture formal arrangement of the buildings express some certain values and transfer the architects' arguments through spatial qualities. This kind of approach cannot be achieved without special attentions to structural concepts. Many landmark and remarkable buildings are created by considering building structure as dominant concepts and exposed elements; Santiago Calatrava is a contemporary architect who has designed many buildings by using this attitude (Ward2009). Hence, according to the existing

documents and data bases necessity of having the ability of integrating structural principles with building design concepts for architects seams explicit.
Moreover, the role of architecture education in this regard has been always attended. Salvadori (1967) emphasizes the necessity of structural knowledge for architectural students and considers it as an essential outline from early education stage. Because of the critical role of architecture education in teaching of structural concepts, arrangement of architecture curricula[1] and also minimum requirements for an architectural curriculum have been attended in this research.

2.1. Structural principles within architecture curricula of some universities in different parts of the world

Six universities from different parts of the world are chosen and their curricula have been attended here. Selection of the universities has been done in a way that the chosen universities have the best rankings in their countries, and even some of them have the highest rankings of the world (please refer to table 1).
The course arrangement of these curricula might not be applicable for EMU or even other universities; however, basic structural thoughts and essential technical issues of them can be inspiring and referable for updating the EMU architecture curriculum.

[1] As well as structural principles of architectural design, some other principles which are indirectly related to structural and technical issues of architecture and can help architects to convert their ideas into reality such as technological, constructional and practical issues of building design are considered in this curriculum survey.

Table 1. Structural principles within architecture curricula of 6 universities in different parts of the world.-Retrieved by referring to the official websites of the universities.

NAME	DEGREE	TECHNOLOGICAL & STRUCTURAL TOPICS IN VARIOUS YEARS
1 MIT (USA)	BACHELOR OF SCIENCE IN ARCH. DESIGN	5 → 1 (colleague) : Chemistry, Physics, Calculus 4 → 1&2 : building technology 3&4 : focus on a specific branch ; such as Building Technology
2 HARVARD UNIVERSITY (USA)	MASTER OF ARCH.	5 → 1 (colleague) : Calculus or higher-level mathematics + Physics 4 → 1 : studio focus on building technology 2 : studio focus on building structure 3: elective courses in building technology 4
3 JORDAN UNIVERSITY OF SCIENCE & TECHNOLOGY (JORDAN)	BACHELOR OF SCIENCE IN ARCH. ENGINEERING	prerequisite: math & physics in high school + 4 years : Math, Calculus, Physics, Structural & technological courses e.g. construction & material, structural analysis, professional practice, engineering mechanics, mechanical systems
4 SHAHID BEHESHTI UNIVERSITY (IRAN)	BACHELOR OF SCIENCE IN ARCH.	prerequisite: math & physics in high school + 4 years:Building material & services, site management, math, statics, strength of material, construction & regulations
5 UNIVERSITY OF CAMBRIDGE (UK)	BACHELOR OF ARCH.	4 → 1 (colleague): Mathematics at A level 3: Principles of construction, structural design & professional practice
6 TECHNICAL UNIVERSITY OF BERLIN (GERMANY)	MASTER OF SCIENCE IN ARCH.	5 → 3 (bachelor) : Design & construction, Structural theory, Building material, physics & equipment 2 (master) : Historical construction & material, Public construction law & project management, Structural design

2.2. Definition of minimum structural requirements in architectural curricula by different architecture education organizations

In today's architecture provision of cooperation between different architecture schools is necessary as it enables students to use exchange programs and cooperate with each other. This requires some similarities and unifications in architecture curricula of different universities. European Union has planned to do this for its members. However, proposing completely equal curricula in the universities is not a good approach since every country and university has its own specifications and cultural properties. Instead some considerations can be applied to provide minimum requirements in all curricula. Definitions of minimum requirements given by some organizations are marked below:

A)Minimum requirements defined by EAAE:
EAAE (European Association for Architecture Education) emphasizes that education and training leading to diplomas, certificates and other evidences of formal qualifications shall insure the acquisition of 11 competences mentioned in the architects Directive 85/384/EEC of EAAE(Directive 2005).
It is not possible to specify some items of the Directive as specific structural and technological requirements because they are interrelated to each other in a design project and cannot be regarded separately, but some of them highlight the important structural and technological concerns of design such as the first, second and the eighth items; the important mentioned key words are: structural design, construction, engineering, technology and association with building design
B)Minimum requirements defined by ACQA:
Minimum requirements for an architecture curriculum have been attended by the ACQA[2] system proposed by TU/e in Netherlands. The mentioned items in this proposition are: capability to analyze, synthesize, abstract (induction) and concretize (deduction). (Meijers 2005)
C)Minimum requirements defined by NAAB:
Another organization which has identified the minimum requirements of architecture curriculum is the National Architectural Accrediting Board (NAAB) in the USA. Within the minimum requirements of architecture curricula defined by NAAB, there are some requirements related to structural and technological principles of architecture, which are marked bellow (NAAB 2004):

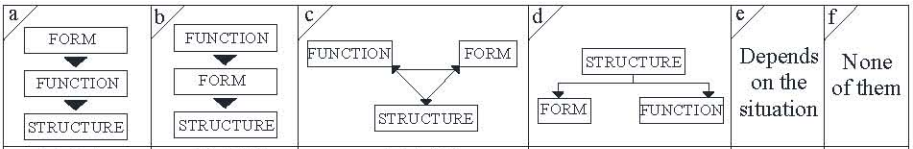
- Comprehending of principles of structural behavior in bearing gravity loads and lateral forces and the evolution, variety, and suitable application of contemporary structural systems.
- Comprehending of the basic principles and adequate application and implementation of building materials for envelope of buildings and assemblies.

3. STRUCTURAL PRINCIPLES WITHIN THE ARCHITECTURAL CURRICULUM OF EMU FROM THE POINT OF VIEW OF EMU ARCHITECTURE STUDENTS

To explore and realize the expectations, needs and ideas of EMU architecture students in relation to structural and technological concepts covered within the EMU bachelor of architecture curriculum a questionnaire is prepared. Quantitative and statistical information which are taken from these questionnaires can be helpful in the future to fill in the gaps and compensate the probable missing points of the curriculum. Since the respondents are expected to have the experience of dealing with the majority of topics covered in the curriculum, they are chosen from the 7th semester (arch 491- Architectural design studio V), 8th semester (arch 492- Graduation design), master and PHD students who are graduated from EMU. Total number of respondents of the questionnaire is 110 persons. Information, results and interpretations of the questionnaire are presented here as following:

[2] AcademischeCompetenties en Quality Assurance

A)Preference of students on the schematic proposed diagrams for architectural design process:



8.18%	13.63%	56.36%	2.72%	6.36%	2.72%

Figure 1. Comments of respondents on the preferred design process

According to figure 1 majority of students (56.36%) believe in parallel attention to form, function and structure in a design process (option c).

B)Students' votes on the quality of teaching of concepts related to function, form and structure in EMU faculty of architecture;

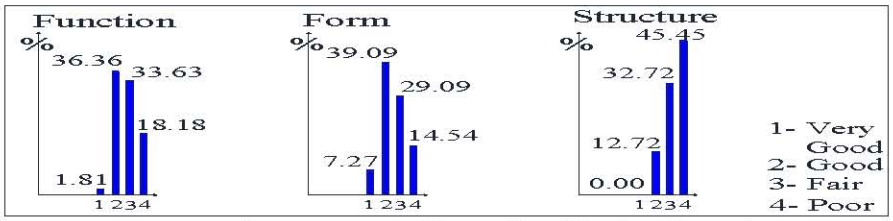


Figure 2. EMU students' votes on teaching quality of function, form and structure

Here, the function diagram reveals the fact that the highest level of satisfaction (very good) exist in a small percentage; however, majority of responds lie in the good and fair category with less than 20% believers of poor performance. This can be regarded as an acceptable situation although there is still space for enhancement. The form diagram configures the order from the lowest to the highest rank as very good, poor, fair and good. The poor percentage is less than 15% and the highest vote goes for good. The overall situation can be evaluated as acceptable although similar to the function diagram still some enhancements are potential to apply in the curriculum. The last diagram (the structure diagram) demonstrates a significant difference in compare with the first two. There is no comment indicating very good and the highest responds goes for the poor option (45.45%). The good option has fewer believers than the fair. Therefore, the situation discloses a need for review of the situation of teaching of structural concepts to promote the current situation of the curriculum.

C)Evacuation of the respondents from the existence of structural resource books for architects and architectural students to get enough knowledge of structural design which can help them in the design projects;

Table 2. Evaluation of existence of structural resource books from the point of view of EMU students.

a	There are enough resource books from this type.	10.00 %
b	There are some books from this type, but they are not respondent the whole questions of architects.	41.81 %
c	There are some structural resource books, but they are mainly useable for structural engineers and not architects.	28.18 %
d	There is not any book from this kind.	7.27 %

In this question as it is shown in the table 2, the option (b), (c) and (d) are indicating that students of architecture have some levels of difficulty in having access to structure reference information and the option (a) mentions that there is no problem to attain structural information from the resource books.
Since only 10% of the students have chosen option (a) and the rest have chosen the other options, it can be thought that architecture students have difficulty and trouble in finding enough structural resource information. This will be further discussed in compare with the instructors' comments.
D)Evaluation of the respondents on the ability of EMU architecture students to define the following items asked about the design studios;
a-Selection of suitable structural system for your selected forms
b-Selection of suitable structural materials (e.g. steel, concrete, wood, composite material) for your selected forms
c-Defining the approximate size of structural members (e.g. size of beam, column, slab thickness, space frame depth and cantilever length)

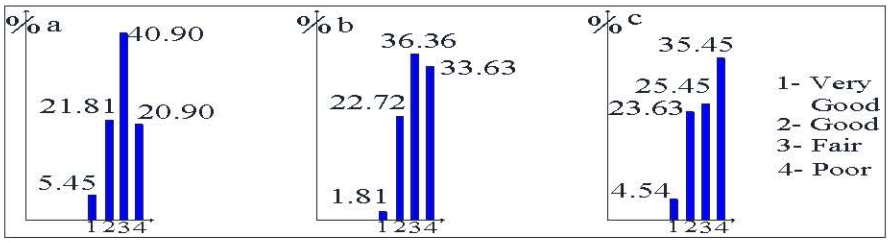


Figure 3. Evaluation of the respondents on the ability of EMU architecture students to define the mentioned a, b and c options

In all of the three diagrams number of people who have voted for fair and good options are more than the people who believe in very good and good situations. Thus, some rearrangements would be beneficial. The third diagram is related to the ability of students in calculation and estimation of structural members' size, which requires the knowledge of physics and mathematics and needs to be attended in further curriculum arrangements.

4. STRUCTURAL PRINCIPLES WITHIN THE ARCHITECTURAL CURRICULUM OF EMU FROM THE POINT OF VIEW OF EMU ARCHITECTURE INSTRUCTORS

In order to evaluate the level of teaching of structural and technical principles within the EMU courses, some interviews have been conducted with EMU architecture instructors. Their view points, expectations and suggestions are mentioned and summarized here in table 3. The interviewed instructors are chosen from persons who are experienced in various branches of architecture; such as structure, construction, urban design, landscape design and environmental control. Therefore, the interview results come from persons with various opinions and can explain the instructors' ideas in general.

Table 3. Summery of the interview results with EMU architecture instructors

COMMENTS	KEY RESULTS
1 Level of teaching of structure	• Very Good: 14.28% • Fair: 14.28% • Good: 28.57% • Poor: 42.58%
2 Comments on positive points	• Students are asked to think about form, function and structure simultaneously from the first stages of design. • There is integration between structural courses and design courses, because teachers who teach structural courses go to design studios as well.
3 Comments on problematic points	• Structural courses are not well integrated into design courses. • Although, there are some useful topics, still there are many missing points and students are not able to deal with structural problems of design studios well. • Students have problems in estimation of structural members' size. • Timing arrangement of the design classes has some problems; just after midterm juries students start to work on structural aspects. • There is not a suitable balance in teaching of form, function and structure. Form and function are more attended than structure . (imbalance)
4 Suggested solutions	• Collaboration between faculty of architecture and civil engineering, this can be done by some courses in department of architecture taught by civil engineers. Also arranging some group projects for students of the two faculties can be useful. • Implementation of some structural softwares in architectural teaching. • Students should be asked to reflect their structural knowledge into their design projects.
5 Existence of structural source books	• No idea ⟶ 14.28% • There are not enough source books ⟶ 14.28% • There are enough source books ⟹ 71.42%

5. PROPOSITION OF SOME PRINCIPLES TO INSURE THE IMPLEMENTATION OF ESSENTIAL STRUCTURAL PRINCIPLES IN ARCHITECTURE CURRICULUM OF EMU

The presented outlines here are reflecting the propositions for updating the school policies in relation to structural principles of architectural design:

5.1.Structural principles within the design studios

In all of the architecture curricula which are surveyed and studied in this research (table 1) structural principles are seen, but in some of them like Harvard University (table 1, item2) there are some special attitudes. In Harvard University, the design studio focus of the second year of architectural studies is specifically given to building structures. This gives the opportunity to students to get familiar with the concepts in the context of design and not just experience them in the theoretical courses. Another application towards integration of structural principals into design studios is seen in the Cambridge University curriculum. In this university, the main emphasize of the studies in the second year is on the integration of technical skills, studio output and ongoing lectures (table 1, item5).By this attitude students are to do two important issues in design studios in the second year. Firstly, application of their structure and construction knowledge (obtained from structure and construction specific courses of the first year of the study) into the design projects; secondly, integration of ongoing taught of the theoretical courses into their design training.

The two mentioned attitudes are parallel to structural and technological requirements that should be fulfilled by architectural schools and have been emphasized by some organizations such as EAAE, TU/e and NAAB (discussed in 2-2).

A similar attitude is proposed for EMU; having one year of design studio focus on building structures is recommended. Integration of structure and construction knowledge of students into the design projects within this year is required. Arrangement of assignments related to structural details and construction drawings for the design courses would be helpful in this period of study. Consideration of practice on building regulations while operating the design is also required.

5.2.Incorporation of theoretical structure and construction courses into the design studios

As mentioned before, EMU students have some problems and difficulties in selection of suitable structural systems and structural materials for their design projects (referring to the questionnaire survey). They also have problems in estimation of the size of structural

members. Thus, it is necessary to consider some requirements to solve these kinds of problems. Moreover, the following propositions rise;

- Interviews with instructors indicate that majority of them believe that there are enough structural source books for architects and they are adequate to respond the students' questions (table 3, item5), while most of the EMU students are not able to solve their structural problems by referring to the source books (table 2); so teaching and focusing on the contents of structure hand books of architecture and inquiring relevant assignments during the theoretical courses of structure and construction is proposed.
- Some of the structural problems of students come from the fragmentation of structure and construction courses from the design studios (table 3, item3). To bridge this gap and have more integration between these two types of courses, it is suggested to give special attention to information about classifications of structural systems and materials and also methods of estimation of structure

members' size in the outline of the theoretical courses (suggestions from EMU instructors, table 3, item4).It would be beneficial if students practice these thoughts on their own design projects.

5.3. Prerequisites of structural and technical aspects of design

To avoid an architectural project from becoming just the outcome of inspiration, the logical analysis must be the first consideration. This viewpoint began with the methodology of architectural design by theoreticians Geoffrey Broadbent (1971) and Christopher Alexander (1964) oriented in a rationality composed of three stages: analysis, synthesis and appraisal. This systematic technique provides a precise evaluation of the conception and building processes and unites logical analytic judgments and emotional creative intentions. This issue has been argued by (Consiglieri V. and Consiglieri L. 2003)in a research emphasizing the importance of existence of mathematical studies in architectural curricula. As has been indicated in that research, it is necessary to enrich the theoretical knowledge in students together with the capacity of application of mathematics in architecture curricula.

Eventually, by referring to the mentioned points and also table 1, a suggestion is made to ensure the fulfillment of necessary prerequisites of structural and technological courses in the EMU architecture curriculum; testing the ability of students in handling mathematical and analytical topics through qualification exams before the first semester of architectural study (revision of entrance regulations of EMU)[3].

5.4.Information Technology (IT) and the new potentials in architecture pedagogy

In today's pedagogy, information technology can play important and effective roles in increasing the quality of teaching. Maier (1998) in the book "Using technology in teaching and learning" emphasizes the role of technology on enhancement of the university programs. As he claims, provision of better access to learning sources is one of the benefits of IT in education.

As has been previously stated, in this research two of the significant out comes obtained from the evaluation of EMU students' abilities from the questionnaire are:

- Necessity of assisting students in using the structural resource books
- Necessity of provision of structural, technical and practical skills in the students

Already there have been some implementations towards solving similar problems in students and assisting them in learning structural taught and skills. Although, they are mainly used by students of the field of structural engineering, the concepts and ideas can be beneficial and applicable for architecture as well. The usage of supplementary online environments, parallel to design studio taught would be positive towards this aim.

[3]By referring to the studied universities in this research, it might seem more useful to propose a systems similar to a curriculum which offers the same architecture degree as EMU (like Cambridge University with Bachelor of Architecture), but since there is no college level in EMU, proposing the fulfillment of mathematics based courses in the college level the same as Cambridge seems inapplicable for EMU.

6. CONCLUSION

Architecture pedagogy has been always faced with two major aspects of design; structural and technological issues of design versos aesthetical values. Integration of these two and providing a sufficient balance between them is an essential concern in provision of successful architectural education systems. Hence, evaluation of the existing architecture curricula in this regard will be helpful and efficient for architectural trainings.

Curriculum of Eastern Mediterranean University has been subjected to this research and is inspected in terms of teaching of structural principles. Current situation of EMU architecture curriculum and the abilities of students are studied and compared with some existing literature and curricula. Consequently, a set of statements and suggestions are made to increase the quality of teaching of structural principles within the architecture curriculum of EMU.

The suggestions items are intended to compensate the missing points and lacking requirements of EMU architecture curriculum and update its contents with the latest contemporary requirements. However, it is necessary to have frequent soundings from the students and also instructors in the future to evaluate their satisfaction from the teaching quality of different structural courses and eliminate the probable problems. From the other hand, this study have had some limitations in terms of the number of studied curricula from around the world which has happened due to the restriction of the research time and also the number of the interviewed instructors due to their availability during the course of this research. Conducting some similar researchers on the EMU architecture curriculum with referring to the limitations of this research and the new requirements of future would help the curriculum to stay efficient and productive for both students and instructors.

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