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Relation of the Structural Design and Architectural Design in Architectural Education: A Survey among Undergraduate Students

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Abstract

Architectural education is a vital part of being a building designer. The courses and curriculum differ among universities at a level. However, the courses supporting design education are parallel with the work of vocational practice. One of the important fields is structural systems that are integrated with building design. It is not only the work of structure engineers; in varying shared work, the architects take the responsibility and role for shaping the structural layout and the system of the building. So, the education program is affected by this fact in most universities, and the architects and lecturers know the importance. This study investigates undergraduate students' approaches and thoughts on the relationship between architectural and structural design. The structured survey asked about the knowledge level, roles, works, and structural courses in education. As a major outcome, the students know that the architectural and structural design processes are not independent and should be executed together. The revealing results are presented and evaluated in the study. The study's main contribution is being the snapshot of students on discourse, which can also be expanded by involving more students from diverse universities.

1. INTRODUCTION

Architectural education dates back to the 1st century BC, as evidenced by Vitruvius's work "De Architectura Libri Decem." In the first book, which he referred to as "Architectural Education," Vitruvius associated architecture with various fields such as geometry, linguistics, history, philosophy, music, medicine, law, and astronomy, asserting that a proficient architect should possess knowledge in these disciplines [1].

When we look at the historical development process of architectural education, we can essentially identify three distinct periods. The first period is characterized by the absence of formal architectural schools, where education was imparted through the master-apprentice relationship. The second period marks the establishment of architectural schools and the provision of theoretical education. An example of this period is the Beaux Arts model, where education was divided into two groups. Practical training was conducted outside the school in craft workshops, while theoretical courses such as design, geometry, statics, construction systems, architectural history, and theory were taught within the school [2], [3]. The Bauhaus, established in 1919, represents an example of the third period. In this educational model, practical courses were introduced within the school, and design studios became a significant component of the education [4]. The Bauhaus approach emphasized integrating arts and crafts, combining various disciplines such as architecture, fine arts, and applied arts. It promoted the idea that architecture and design should be closely interconnected, emphasizing functionality and innovative use of materials and technologies. Architectural education started in a transformative process after 1950. Techniques from geometry, mathematics, and system analysis were introduced into the design process, along with participatory and pluralistic approaches [2]. Architectural design studios began implementing techniques and methodologies beyond formal or spatial creativity. While creativity in form and space often takes the forefront, creative exploration within

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the structural context is frequently overlooked. However, the structural context is fundamental to architecture, serving as a cornerstone and a definitive norm among the shaping forces of architectural design [5].

Despite being integral to architecture, architects and civil engineers often perceive structure differently. In engineering, structure is defined as a functional building component, whereas architecture strives to encompass the formal, functional, spatial, and contextual characteristics of a building as a whole. Besides, many building typologies such as warehouse, train station and bridges have been gotten much related to civil engineers since their structural components came in front [6]. Thus, an understanding of two different works on spaces and structures is existed. This approach is similarly reflected in the undergraduate education of both disciplines. Architectural design studios typically emphasize spatial design, with the consideration of structure coming into play later in the design process [3], [7], [8]. But there are also important thoughts of the students that the implementation of structural design to architectural design change has positive effects [9]. Besides, structural design can invigorate the designer's creative inclination to combine materials and forces [5]. However, structural considerations often emerge in the later stages of architectural design.

This research investigates the approaches and thoughts of undergraduate architectural students about the structural and architectural design of buildings. First, a literature survey about architectural education and the integrity of the structure and design was conducted to figure out the research problem. It is important to explore the awareness and approaches of architectural students about the relationship between structure and design since they are the important side of education. Then, a questionnaire survey was set and executed among architectural students under the defined themes. The findings were presented and discussed due to organized themes. As a major outcome, undergraduate students are mostly aware of the importance of structural and architectural design relations. The remarks and statements of research are to enlighten the roles of structure-related architectural design subjects in the actual curriculum.

2. METHOD

In research, survey studies ask many people questions about their behaviors, attitudes, and opinions [10]. The questions, sample group, and survey procedures should be developed according to the study's objectives consistently and accurately. The literature survey exploring the relation of structure and design and architectural design was conducted in the research process to set the objectives and themes of the survey study. Commonly, samples are surveyed through questionnaires or interviews, which can vary from highly structured questionnaires to unstructured interviews [11]. The themes aimed to measure, obtained from literature synthesis, should show the relationship between facts. Quantitative approaches seek factual data to study how such facts and relationships accord with theories and findings of any research executed by literature [11]. Thus, this study developed a structured questionnaire to measure and evaluate the approaches and thoughts of undergraduate architectural students about the structure and architectural design relation under four themes. The themes and questions are presented below;

- Theme 1: The relation of design and structure
    - Q1: Architect must work in design with the integration of the structural system.
    - Q2: Architectural design and structural design are independent processes.
- Theme 2: Works of Architects on Structure
    - Q3: Pre-structural system layout must be done by the architect at the pre-design project stage.
    - Q4: The pre-work of the architect on structural system layout before structural calculations is vital for project success.
- Theme 3: Roles on Structural System
    - Q5: Role and Responsibility of Structural Engineer on Structural System Framework.
    - Q6: Architect does not need to work on structural system. It is the work of structural engineers.
- Theme 4: Knowledge and Education
    - Q7: The needed knowledge level of architects on structural systems

- Q8: The structural courses are vital for architectural education.

The questionnaire survey was conducted between 01/04/2023 and 01/05/2023 by an online announcement to the students of Ankara Yıldırım Beyazıt University Architectural Department[1]. The department has approximately 270 students: 100 in the first, 70 in the second, 60 in the third class, and 40 in the fourth class. In the department's curriculum, major structural courses start in the first semester of the second class and finish in the second semester of the third class. The curriculum is shown in Figure 1. Personal information and participation records were not kept, and this was given with the announcement of the survey. The questions' order was given randomly, independent from the themes' order. The choices are set from "0" to "6", in which "0" means "no" and "never"; "3" means "indecisive" and "neutral"; "6" means "yes", "completely" and "always. The results are discussed for the evaluation of the responses for all themes. Besides, the total score for themes is evaluated with a distribution of students' education level.

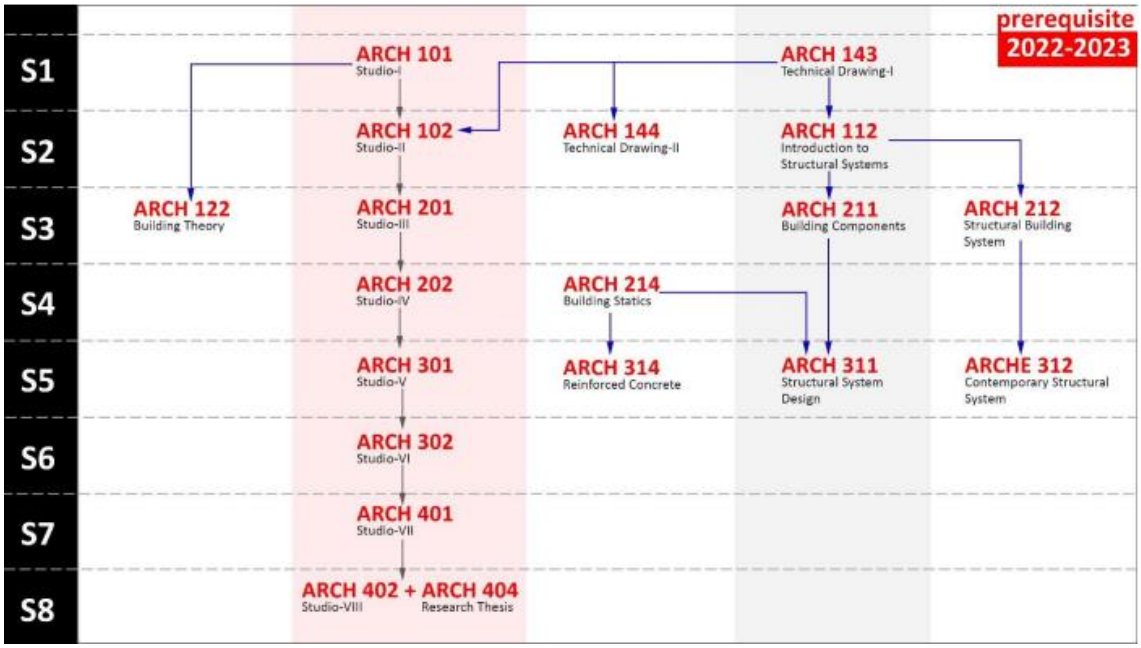

Figure 1. *The curriculum of the Department* [12]

3. ARCHITECTURAL EDUCATION AND STRUCTURE

The architecture department's curriculum includes a significant amount of design studios. The core of architectural education comprises these studios, where students combine and apply the technical and theoretical information they have learned in prior classes. [13], [14]. It is the first area where difficult challenges involving comprehending the issue, looking for causes, controlling outside factors, and balancing curricular requirements are presented to students. [15]. Despite the provision of supportive courses such as building technology, statics, and structural systems within architectural education, the knowledge acquired in these courses often struggles to find significant resonance within architectural design studios [8], [16], [17]. The primary reason for this lies in overseeing the structural system's influential role beyond being a load-bearing element, which shapes architectural form and space.

Primitive and basic structures created by early humans using readily available materials in their environment to simplify their lives can be considered the genesis of architectural production [18]. Over time, the transition from a nomadic to a settled lifestyle among hunter-gatherer societies strengthened intercommunity communication, leading individuals to share their experiences. This sharing of experiences

[1] The ethical approval of survey was taken from the Ankara Yıldırım Beyazıt University with decision no: 2023-02

among human communities extended to architectural production, enriching the field through transmitting knowledge, which led to enhanced products [1].

According to Clark and Pause (2005), elements such as columns, walls, floors, and beams have been employed to define space, create units and modules, facilitate circulation, or establish architectural compositions [19]. Similar to Clark and Pause (2005), Charleson (2005) also view structure as an element that enriches architecture [20]. Similarly, Engel (2004) characterizes structure as one of the cornerstones of architectural design due to its impact and contribution to maintaining the formal integrity of a building. Thus, structure emerges as a significant element among the forces shaping architectural form, opening up numerous possibilities and interpretations for generating architectural form and meaning. In Engel's proposed model, the determinants of the structural system encompass not only architectural program, space, and form but also mechanical, technical, social, and economic considerations, as well as laws, regulations, and standards [5]. Collaboration has always been required between architects and those with the technical expertise to realize buildings. The nature of the relationship has taken many forms, and the form in plat at any time has always influenced the nature of the interface between structure and architecture [21]. Besides, structural elements may have vital roles in architectural design beyond being only standing elements if the designer implements the formal and governing roles of the structural system [22]. With material and applications, structural system not only makes building stand, but also make building live [23].

During a certain period, there existed the role of the "Master Builder," who was responsible for every aspect of creating a new building. The writings of the Roman architect Vitruvius and studies on the Ottoman Empire's architect Sinan demonstrate that the builders of those times were not only architects but also structural engineers, mechanical engineers, construction engineers, urban planners, and contractors. However, in those eras, knowledge, and technology were limited to understanding a single individual. Over centuries, the knowledge required for designing and constructing a building has exponentially increased due to advancements in science and technology. With development of the new materials and system, and emerging of new building types, the knowledge of designers became insufficient and the need of a structural designer who could be capable of calculating dimension and geometries occurred [24]. The structural design process is composed of two different studies; composition of main form of structural system and defining the ultimate geometry and dimensions of the structural system [25]. Architectural design cannot be thought without the first part of the structural design. Thus, as in the design process structural design is integral part of the architectural design education. There is an also important issue about the objectives of the structural courses in architectural design. They cannot be thought like the education objectives of the civil engineers. The aim is to be as Hunt (2003) said, to develop an understanding of the essential structural principles and behaviors by a descriptive and largely non-mathematical approaches [26]

Although architecture's functional and structural components often differ, the structure has always influenced architecture. First, this is inevitable. Second, structure obeys the laws of nature and cannot always satisfy the architect's desires. Third, even though the structure is necessary, it is often concealed and may not appear to contribute to the architecture it supports. Finally, the structure is costly. In most buildings, the cost of the structure is a quarter or fifth of the total cost, but in some cases, such as a bridge or a large hall, it is even the main cost component [18]. The only task an architect can accomplish without designing a structural system is landscape design or perhaps an outdoor car park. Otherwise, any designed building, roofing system, or floor system requires a structural system, and none can be created without one. Architects and builders rarely design structural elements and systems within their buildings [27]. However, the responsibility of designing this system as the primary creator of the building lies with the architect. Therefore, structural design is also the duty of architects [28], [29].

4. FINDINGS AND EVALUATIONS OF THE SURVEY

This section presents the findings of the questionnaire survey. The results are given under the order of themes. 147 students participated in surveying. The ratio of respondent groups due to classes is shown in Figure 2. Since the enrolled student’s quantity differs, the difference between classes had been expected., however, the response rate is out of the expected. 14% of the respondents are from first class, 40% from second class, 29% from third, and 17% from fourth class. The first class may have a lower participation

ratio since they had not started structural courses. The second and third classes have combatively higher ratios because of enrollment to structural courses at the survey time.

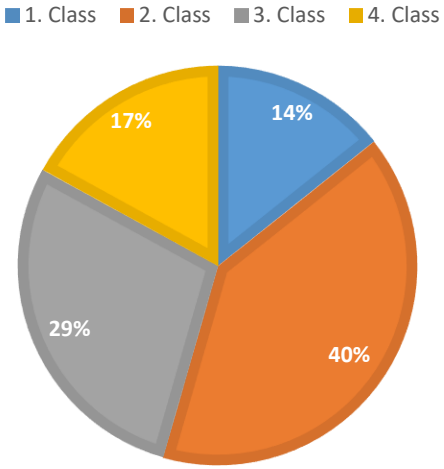

Figure 2. *Respondents due to Classes*

The responses to theme one questions can be observed in Figure 3. 68,71 % of the students noted that architects must work in design with the integration of structural systems. 29,25 % are neutral, and only 2% of them are rejected. However, thoughts on architectural and structural design dependency are relatively different. 17% thought they were independent processes, and almost half thought processes were not independent. There is 20% difference, which means that students think the need for design work with the integration of the structural system. However, they think the architectural and structural design processes are independent.

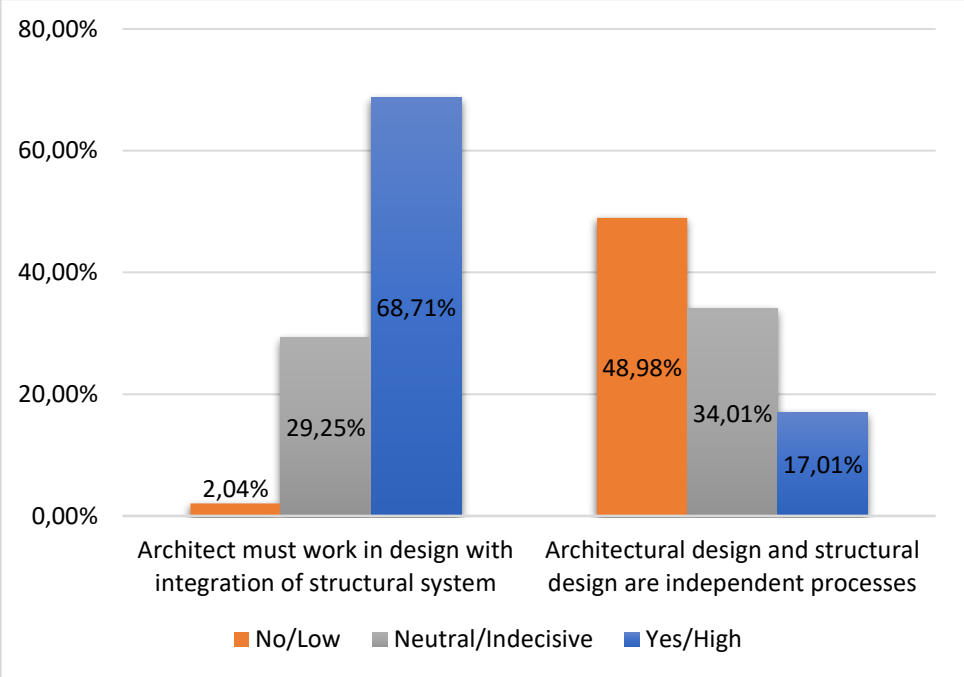

Figure 3. *Design and Structure Relation*

Figure 4 focuses on the work of architects on the structure. The responses' ratios are similar for the two questions. Approximately 60% of the students stated that the work of the architect on the structural system is vital and must be done before structural calculations for the project's success. However, over 30% are neutral, and approximately 4% thought negatively. The consistency of answers is important. On the other hand, the ratio of around 60% means that another stakeholder should design the structural layout of their designs.

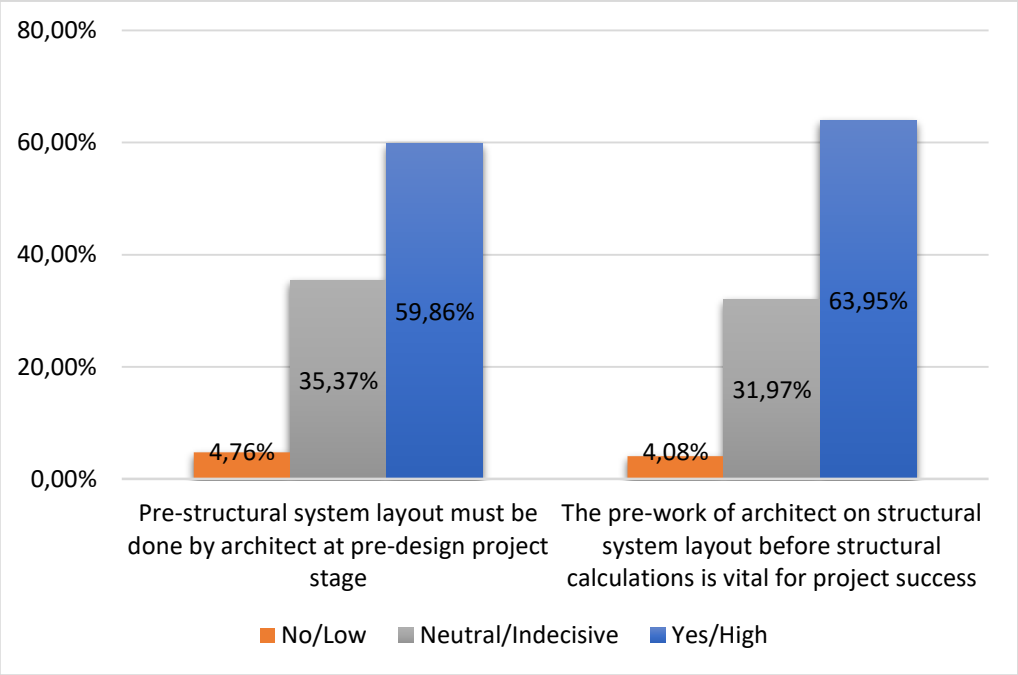

Figure 4. *Work of Architects on Structure*

The roles of architects and structural engineers in structural systems were asked in theme 3 with two questions. Figure 5 indicates the responses of students. 74.15 % stated that the role of structural engineers in structural systems is high, and 23,81 % is neutral. They underlined the responsibility of the engineer. Reasonably, they figured out the architect's role in the structural system by 63,95% response ratio to question two. The neutral responses are between 23% and 30%.

In Figure 6, the knowledge of structural systems and education was explored. 51,02% of students thought the knowledge level should be high, 2,04% stated low, and 46,94 % were neutral. On the other hand, 77,55% thought that structural courses are vital for architectural education. 19,73% are neutral, and 2,72% thought courses are unimportant.

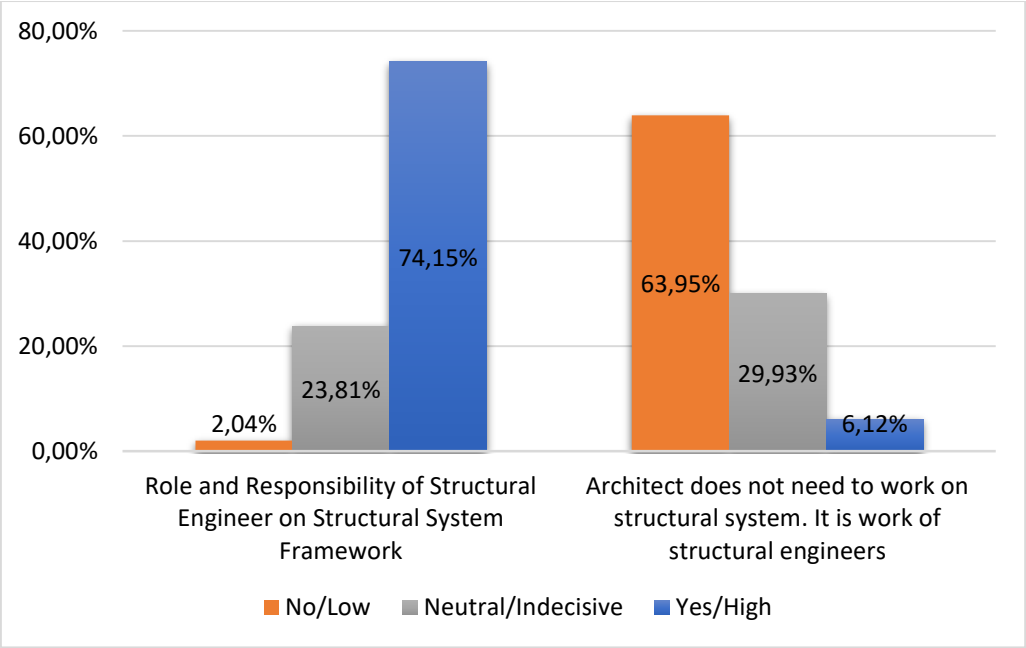

Figure 5. *Roles on Structural System*

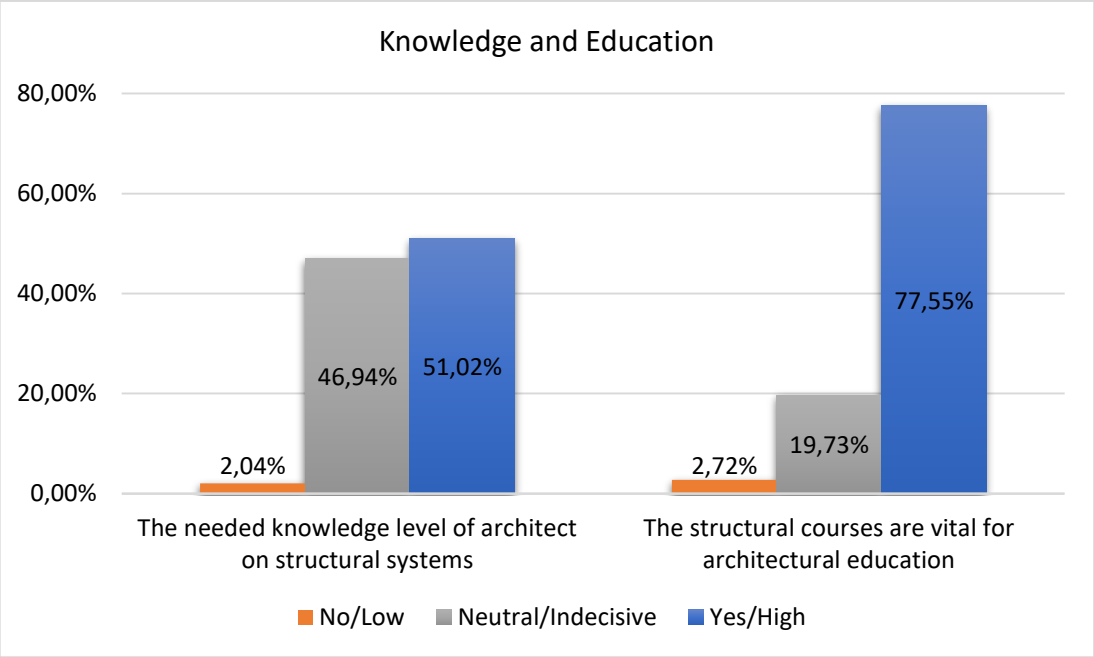

Figure 6. *Knowledge and Education*

Besides the findings on themes, the scores for questions distributed to the classes are important to explore the thought about education level. Figure 7 and Figure 8 point out the scores from "0" to "6" for the eight questions of four themes. For Q1: Architect must work in design with integration of the structural system. First and third-class responses are parallel with the group. The second class is lower than average, and the fourth class is higher. Looking into Q2: Architectural design and structural design are independent processes; it could be seen that the responses are seriously different among classes. Students' thoughts on architectural and structural design dependency increased from the first to the fourth class.

For Q3: Pre-structural system layout must be done by the architect at the pre-design project stage. The important difference is in the second-class group. They have a lower ratio than average. However, for Q4: The pre-work of the architect on structural system layout before structural, the lower score belongs to first-grade students. It increases up to the fourth class, but there is a slight decrease for fourth-class students. Q5: Role and Responsibility of Structural Engineer on Structural System Framework shows that the second-class students gave lower points to structural engineer than the rest. For Q6: Architect does not need to work on the structural system. It is the work of structural engineers; the responses are orderly decreases from first class to fourth class, which means their thoughts on the subject become clear with education. The significant result of Q7: The needed knowledge level of architects on structural systems is the score decrease from first to second, then re-increases and re-decrease to fourth class. There are no main explanations for this situation. However, this change may result from their own course experience. For Q8: The structural courses are vital for architectural education, it could be seen that the awareness of structural courses increases in parallel with the education and enrollment of structural courses.

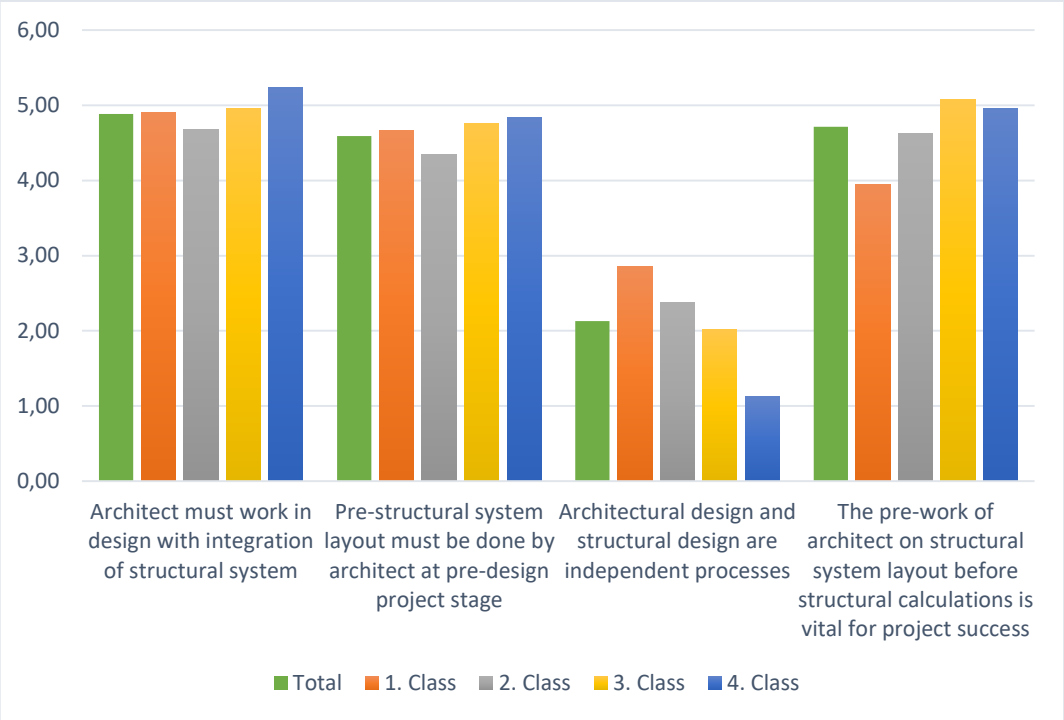

Figure 7. *Scores of Themes 1 and 2*

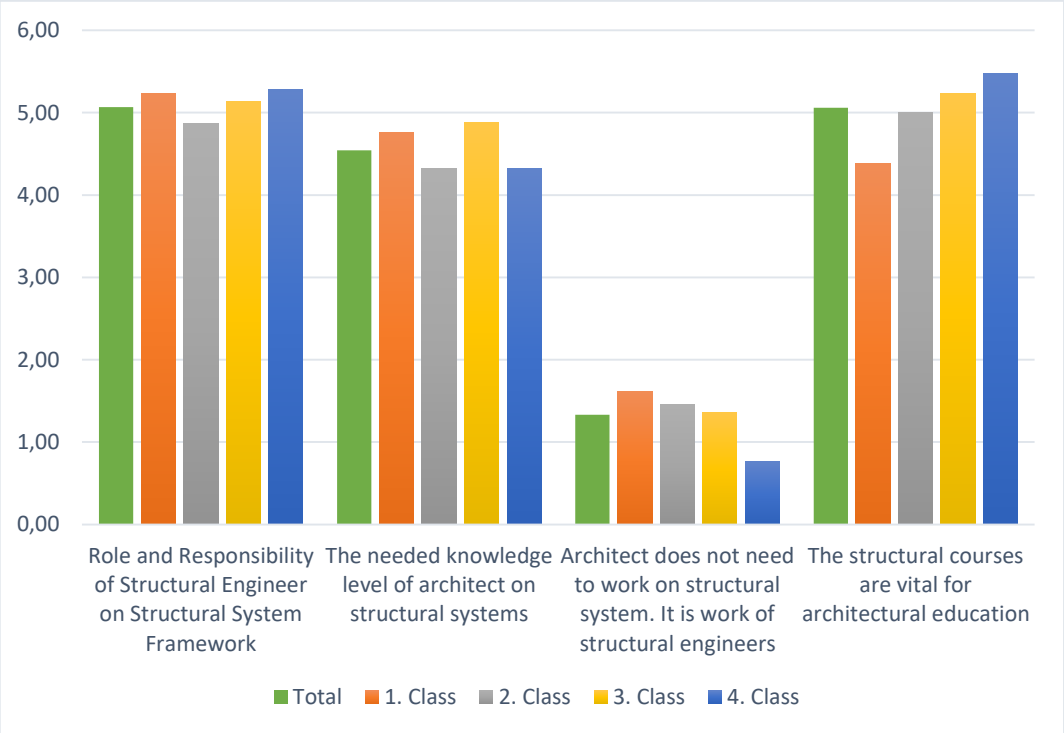

Figure 8. *Scores of Themes 3 and 4*

5. CONCLUSION

Architectural design and structural design works seem to belong the different practitioners. The roles and responsibilities in the field may vary. However, a building design process starts, continues, and is completed with the implementation of rationales of the structural system. Thus, the work of an architect can not be thought of without integrating the structure in projects with relation to form, spatial, and conceptual attitudes. The effect level for executing this work may change due to the architects' approaches, design

processes, and thoughts, but the absence of it is out of concern. Because of facts, structural design, and related courses are vital parts of most universities' undergraduate architectural education. Lecturers and academicians have parallel thoughts and research which support and investigate the architectural and structural design relationship. One of his study's major objectives is to investigate students' thoughts and approaches to this situation.

By looking at the survey results, some significant statements should be underlined. First, most students think and validate that the architectural and structural design processes are not independent. They should be executed within integration, not an exact time order. Secondly, many students learned that the architect's responsibility is the structural layout and pre-design work. It should be noted that 1/1 of them are neutral about this statement. Knowing the work of architects on structural system layout, they also know that it is the structural engineer's responsibility. Besides, some think structural design works are only done by structural engineers, generally from the first-class students. They think that structural courses are vital for architectural education.

On the contrary, it can be seen from the results of theme 4 that the needed level of architects on structural systems is comparatively low. It may result from the courses' loads or not knowing the benefits of the learning, which should be investigated further. The research also presents the scores for asked themes upon different levels of students, which can be further analyzed with the integration of the curriculum outcomes. Because, as general acceptance, the thoughts and skills of the students change over time and the complete education rate. This study is an important snapshot of the architectural undergraduate students' thoughts and approaches to the position of structure and structural-related education in architectural education. While designing and deciding on the curriculum academicians, the students' learnings should also be evaluated near architectural education's theoretical and practical background. The study can show a wider perspective of the case by expanding the survey with the participation of diverse universities and academicians. Students are part of the architectural departments' curriculums; thus, their feedback should also be considered for the education program. The outcomes of proposed further works can be used to evaluate existing courses and their contribution to the vocational practice of architectural students.

REFERENCES

[1] P. Vitruvius, *Mimarlık Üzerine On Kitap (S. Güven Translation)*. Ankara: Şevki Vanlı Mimarlık Vakfı Yayınları, 1993.

[2] B. Uluoğlu, 'Mimari Tasarım Eğitimi Tasarım Bilgisi Bağlamında Stüdyo Eleştirileri', İstanbul Technical University, 1990.

[3] A. M. Salama, *New Trends in Architectural Education*. Raleigh, N.C.: Tailored Text and Unlimited Potentials, 1995.

[4] Ç. B. Dikmen, 'Mimarlık eğitiminde stüdyo çalışmalarının önemi: Temel eğitim stüdyoları', *E-Journal of New World Sciences Academy*, vol. 6, no. 4, pp. 1509–1520, 2011.

[5] H. Engel, *Strüktür Sistemleri*. İstanbul: Tasarım Yayın Grubu, 2004.

[6] M. Rinke and J. Schwartz, *The Ambivalence of The Revolution, Before Steel*. Zurich: Verlag Niggli AG, 2010.

[7] J. M. Homer, 'Integrating Architecture and Structural Design in the Comprehensive Design Studio', *Building Integration Solutions*. pp. 1–15, 07-May-2012.

[8] M. Fahmi.M., A. A. Aziz, and S. E. M. Ahmend, 'The Integration of Structural Knowledge in Studio Design Projects: An Assessment Curriculum in: Architecture Course in SUST', *Journal of Science and Technology*, vol. 13, pp. 59–71, 2012.

[9] F. Maden, 'Mimari Tasarım Stüdyosunda Strüktürün Form ve Mekân ile Entegrasyonu', *Tasarım + Kuram*, vol. 16, no. 31, pp. 108–122, 2020.

[10] G. Marczyk, D. DeMatteo, and D. Festinger, *Essential of Research Design and Methodology*. John Wiley & Sons Ltd, 2005.

[11] F. Bechhofer and L. Paterson, *Principles of Research in the Social Sciences*. Routledge, 2000.

[12] 'Ankara Yıldırım Beyazıt Üniversitesi', 2023. [Online]. Available: https://aybu.edu.tr/mimarlik/tr/sayfa/7667/Kayıt-Kılavuzu. [Accessed: 16-Aug-2023].

[13] G. Ozorhon and G. Lekesiz, 'Re-considering the Architectural Design Studio after Pandemic: Tools, Problems, Potentials', *Journal of Design Studio*, no. 1, pp. 19–36, 2021.

[14] U. Tuztasi and P. Koc, 'Vertical Design Studio in Architectural Education: A Summer Practice on Corner Parcel', *Journal of Design Studio*, vol. 4, no. 2, pp. 163–177, 2022.

[15] N. Caglar and Z. S. Uludag, 'Architectural design education: Designing a library, public communication and information center in the manufacturing zone of Central Eskişehir Turkey, a case study', *International Journal of Art and Design Education*, vol. 25, no. 2, pp. 231–240, 2006.

[16] S. M. Namara, 'Bringing engineering into the studio: Design assignments for teaching structures to architects', in *119th ASEE Annual Conference and Exposition*, 2012, pp. 24.270.1-25.270.12.

[17] A. I. Ünay and C. Özmen, 'Building structure design as an integral part of architecture: A teaching model for students of architecture', *International Journal of Technology and Design Education*, vol. 16, no. 3, pp. 253–271, 2006.

[18] M. Salvadori, *Why Buildings Stand Up: The Strength of Architecture*. New York: W.W. Norton

Company, 1980.

[19] R. Clark H. and M. Pause, *Precedents In Architecture*, Third. New Jersey: Wiley, 2005.

[20] A. W. Charleson, *Structure As Architecture: A Source Book For Architects and Structural Engineers.* London: Architectural Press, 2005.

[21] A. J. Macdonald, *Structure and Architecture*, Second. Architectural Press, 2001.

[22] A. Taşkın and E. Onur, 'Strüktür Bileşeni Olmanın Ötesinde Kolonun Mimari Tasarımda Rolü', *Tasarım + Kuram*, vol. Kasım, no. 34, pp. 14–32, 2021.

[23] E. Allen and J. Iano, *Fundamentals of Building Construction,* Fifth. Wiley&Sons, 2009.

[24] Ö. Kavurmacıoğlu and L. Arıdağ, 'Strüktür Tasariminda Geometri Ve Matematiksel Model İlişkisi', *Beykent Üniversitesi Fen ve Mühendislik Bilimleri Dergisi*, vol. 6, no. 2, pp. 59–76, 2013.

[25] A. J. Macdonald, *Structural Design for Architecture*. Oxford: Architectural Press, 1997.

[26] T. Hunt, *Toomy Hunt's Structures Notebook*, Second. Architectural Press, 2003.

[27] J. Ochshorn, *Structural Elements for Architects and Builders*. Else, 2010.

[28] C. Özmen and A. I. Ünay, 'Architect - Structural engineer collaboration in sustainable Structural System Design', *Gazi University Journal of Science*, vol. 24, no. 4, pp. 919–925, 2011.

[29] A. İ. Ünay and E. Atımtay, 'Developing Earthquake Consciousness in the Architect', in *Architecture and Engineering The Teaching of Architecture for Multidisciplinary Practice,* 1999, pp. 267–270.