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EXAMINATION OF THE BUILDING SCIENCE IN ARCHITECTURE EDUCATION WITHIN THE CONTEXT OF ACTIVE LEARNING METHOD

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Abstract. This article delves into how active learning methods are integrated into architectural education, specifically focusing on the Building Science course. The Building Science course is a crucial component of architectural education and the active learning method offers a practical approach to teaching this course. The study is based on the first-year undergraduate course “M1082 Building Knowledge” at Gazi University, Department of Architecture. In this course, students passively receive information from the instructor and actively participate in learning by designing, drawing and modeling the project on specific subjects. The material of the study consists of 2D technical drawings and 3D models of the works carried out between 2021-2023 and found successful in this course. The participant observation method, one of the qualitative data research methods, was applied in this study while evaluating the selected products. Results indicate that the active learning method enables students to understand structural issues, improve their design skills and transform technical knowledge into practical applications.

Keywords: *Active learning, architectural education, building science.*

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1. Introducion

Architecture is defined as the art of building the necessary spaces with aesthetic creativity by combining functional requirements and technical and economic opportunities so that people can make their lives easier and continue their activities, such as shelter, rest, entertainment and work (Hasol, 1998). According to another definition, architecture is a dynamic discipline open to innovations and constantly changing. The first architectural theory book, “Ten Books on Architecture” (Morgan & Warren, 1914), emphasizes that architectural students should have cultural, scientific, historical, environmental, intellectual and social knowledge. The fact that architect candidates/students have this knowledge and are better equipped in their professional lives is related to good architectural education.

The aim of teaching in architectural education, which includes science, art, technology and the humanities, is to train professionals who can make decisions to provide appropriate solutions that meet users' physical and psychological needs (Yalaz, 2021). Unlike other sciences, architectural education requires a study based on students'

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physical and sensory structures. In this way, it aims to develop the ability of the student's mind, eye and hands to work together.

During the architectural education process, which forms the basis of professional life, students should be equipped with sufficient technical knowledge and practical skills to develop strategies to overcome the difficulties they may encounter in professional practice (Deshpande, 2008). Application in architecture involves a process encompassing aesthetic, functional and technical design. As the technical design process is linked to engineering fields, it also coordinates with different disciplines. Architects should have sufficient knowledge of structural systems and structural design approaches to control the physical environment, ensure coordination between disciplines and design aesthetic, flexible and functional architectural work. Therefore, the architect's adequate knowledge of technical solutions affecting the building application process is related to the Building Science course taught during the architectural education process.

It is a common problem for architecture students to need help understanding structural issues and basic concepts (Charleston, 2005; Chiuini, 2006). This situation causes architect candidates to be unable to communicate correctly with engineering fields and make technical analyses correctly in their professional lives. Educating architects to be aware of structural functions, correct load transfer and the appropriate sizing of building elements is linked to the use of accurate and effective learning methods in Building Science courses (Salvadori, 1958; Salvadori & Heller, 1986; Allen, 1997; Vassigh, 2005; Salama, 2008; Wetzel, 2012; Uihlein, 2013; Sgambi *et al*., 2019). To enable future architects to interact with engineering disciplines and conduct precise technical analyses in their professional careers, the difficulties architecture students encounter in understanding structural principles and fundamental concepts must be addressed.

Various active learning experiences have been developed in architecture courses, especially in Studios, where the teaching environment is more suitable for active learning teaching and it is aimed at teaching Building Science courses effectively with these learning methods (Mohareb & Maassarani, 2018; Qureshi, 2019). In this context, this study uses active learning methods to deal with a Building Science course at Gazi University Architecture Department. Within the scope of the Building Science course, after the theoretical lecture, to improve the student's understanding of the primary structural concepts, in-class practices and the active learning process encouraged were examined.

2. Active Learning

Learning is an active process fed by experience and students need to be at the center of learning in acquiring knowledge and skills to realize effective learning (Nicol & Pilling, 2000). On the other hand, it is essential in the education process for educators to determine the most appropriate learning method or teaching strategy by understanding students' learning styles (Dassah *et al*., 2018; Yalaz, 2021). Effective and responsive education is built on this dual emphasis on pedagogical flexibility and active student interaction.

When the historical evolution of architecture and its teachings are examined, it is said to be a collaborative and problem-based learning activity that is built on both theory (thinking) and practice (doing) (Djabarouti & O'Flaherty, 2019; Khodadadi, 2015). Architectural curricula are constructed mainly using a similar approach. Robert (2006) argues that a healthy mix of theory and practice is the most beneficial approach for architecture students to become well-rounded, competent and creative designers. Other studies emphasizing the use of active learning methods in architectural education (Ching, 2007; Ciravoğlu, 2014; Andújar-Montoya et al., 2017; Yalaz, 2021) state that in architectural education, where applied education is at the forefront, it is necessary to utilize active learning methods in which students become the focus of the course rather than just listening to the lecture.

Active learning is generally defined as any teaching method that involves students in the learning process (Bonwell & Eison, 1991). Another definition states that it is a process in which the learner is responsible for the learning process and is allowed to make decisions and self-regulate the learning process (Şimşek, 2015; Açıkgöz, 2014). Therefore, active learning requires students to engage in meaningful learning activities and think about their actions (Prince, 2004). The active learning process aims not to impose knowledge on the student but to mediate their ability to achieve something independently (Yurtsever, 2011). Thanks to the dynamic relationship, individuals can gain self-confidence and express themselves more efficiently and a natural sharing environment will emerge (Yurtsever, 2011; Lubbers & Gorcyca, 1997; as cited in Güneyli, 2007). When the literature on active learning methods is examined, the following parameters appear: Making experiments, In-class written exercises, Games, Problem sets, Audience-response systems, Debates, Class discussions, Problem-based learning, Case studies, Group work, Simulations and Cooperative learning.

Within the scope of the study, active learning methods were examined in the context of architectural education. Many insights have been gained on how the methods used in this context can improve students' learning experiences in architectural education and how they can better grasp architectural concepts and skills.

Studies supporting experiential learning (Mayuk & Coşgun, 2020; Yalaz, 2021; Durukan & Açıkel, 2020) argue that implementing "learning by doing" in architectural education through courses, internships and workshops will contribute to students integrating different skill sets and gaining various benefits from working in a more open environment outside of school.

Problem-based learning is another active learning method that has been evaluated for promoting the creative problem-solving abilities of undergraduate structural engineers. McCrum (2016) assessed the efficacy of active learning strategies, such as active engagement with content knowledge and physical conceptual structural models, in promoting higher-order problem-solving skills and reinforcing key concepts using interdisciplinary problem-based learning.

Virtual reality (VR) and immersive learning are two examples of technology used in architectural education. Ibrahim et al. (2021) investigated the impact of VR technology on students' learning capacities in architectural history courses. Including VR technology increased students' engagement and understanding of architectural history by providing a more immersive and dynamic learning environment. Şahbaz (2021) discusses using VR in architectural education through a construction studio simulator.

As a form of active learning, computational fabrication techniques have been included in architecture education. The approach and outcomes of exercises about the undergraduate use of computational fabrication tools and methods were shared by Oktan and Vural (2022). Through this integration, students could actively use digital tools and gain functional architectural design abilities (Oktan & Vural, 2022).

Architectural education has also incorporated collaborative learning techniques. The topic of interactive stakeholder participation in design studio education was covered by Dhadphale & Wicks (2022). The methodological design encouraged students to actively collaborate and engage by drawing from numerous sequential generative activities (Dhadphale & Wicks, 2022). Wu et al. (2014) discuss a study on the architectural design learning process focusing on social learning, lesson teaching, interaction and analogical thinking. The findings offer insights into the impact of active learning methods and collaborative learning approaches in architectural education.

These articles provide insightful viewpoints on the various circumstances in which active learning techniques might be implemented to improve architecture education. By actively involving students in practical exercises, problem-solving challenges and leveraging technology, active learning fosters a more profound comprehension, stimulates critical thinking and nurtures the development of practical skills. The infusion of active learning techniques into architectural education enriches students' learning experiences and prepares them for the practical demands of real-world architectural practice.

The following section explains how the Building Science Course subjects are handled using active learning methods supported by examples.

3. Teaching Building Science Subjects with Active Learning Method

Active learning requires students to work at higher cognitive levels by analyzing, synthesizing and evaluating during learning tasks. This approach contrasts with traditional lecture-based teaching, where students receive information passively. This paper explores the use and advantages of active learning within the framework of a building science course in architecture. The study is based on the first-year undergraduate course "M1082 Building Knowledge" at Gazi University Department of Architecture. In this course, students passively receive information from the instructor and actively participate in learning by designing, drawing and modeling a project on a specific subject. The material of the study consists of 2D technical drawings and 3D models of the works carried out between 2021-2023 and found successful in this course. The participant observation method, one of the qualitative data research methods, was applied in this study while evaluating the selected products.

Gazi University, Faculty of Architecture, Department of Architecture, the "M1082" coded "Building Science in Architecture" is the year one course of architecture undergraduate education. There are no prerequisites for students to take the course. The course flow chart is given in Figure 1.

Building Science in Architecture is an applied course. After the theoretical lectures, the students are given project applications to solve various problems. The course, which has four credits and six ECTS, continues for 14 weeks during the semester and lasts six hours, with two hours of theoretical knowledge and four hours of practice per week. As it is an application-oriented course, each student's performance in the workshop is a critical evaluation criterion at the end of the semester. In the practice course, students are divided into groups of 10-12 people on average. Each group includes an executive lecturer. Students improve their studies by receiving criticism from executive lecturers.

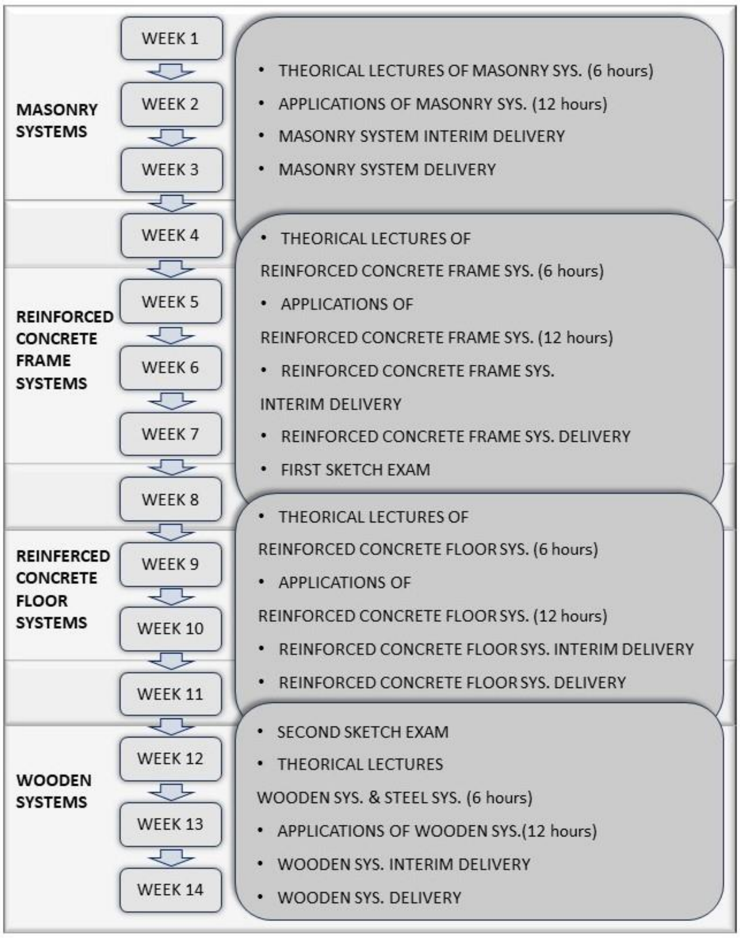


Figure 1. "M1082" coded "Building Science in Architecture" Course Flow Chart

There are five subject headings in a semester of the Building Science in Architecture course. These subjects are: 1. Masonry systems; 2. Reinforced Concrete Systems; 3. Floors; 4. Wooden systems and 5. Steel systems. There is no application drawing, only under the title of steel systems. This study will be carried out in the Building Project Studio course in the upper semesters. A four-week time frame is given for each subject.

The application work covers a total of 16 hours and 4 hours, respectively. In the theoretical lecture parts of the course, information is given for each subject, from basic information to details for five main topics. Traditional and innovative system solutions and materials are mentioned in detail. Detailed presentations are given on the drawing techniques of the systems and how they are made in real life, including drawings and visuals. In line with the subject title, 2D technical drawings and 3D model applications are made, which include solving problems based on theoretical knowledge. In this process, for detailed solutions, students make an interim delivery to the group lecturer and receive criticism of their drawings. After the interim critical phase, the drawings are returned to the students for revision. At the end of four weeks, a 1/50 scale model and 1/50 scale plans, sections and views are completed and delivered. After all the studies on the subject are submitted, a new topic is started and the process continues similarly for the four topics. In addition, two sketching examinations were conducted during the semester. Thanks to the sketch exam, students' ability to think and solve problems in a limited time without a lecturer is measured.

In the final evaluation at the end of the semester, each student's technical drawings, models and two sketch exams of Masonry Systems, Reinforced Concrete Systems, Flooring and Wooden Systems are graded with specific percentages. Thus, within the scope of the Building Science in Architecture course, the skills of two-dimensional and three-dimensional thinking, perception, problem solving, dexterity development and putting professional theoretical knowledge into practice are added to the students.

At Gazi University Architecture Department, where Building Science education is handled intensively and predominantly, the four main subjects of the course, which form the basis of the building education process in undergraduate education–Masonry Systems, Reinforced Concrete Systems, Flooring and Wooden Systems–are explained in detail in this section.

3.1. Masonry Systems

In the masonry system, carrying the load and separating the spaces are gathered on the same building elements (Hasol, 1998). In this system, which is the first topic of the Building Science course, students are primarily informed about the wall-bearing systems (masonry systems) and the primary applications of these systems. Material types, such as stones, bricks and briquettes, are explained when the subject's content is examined. Moreover, the usage patterns of these materials, types of building walls, technical information on the structural system setup, maximum and minimum dimensions, wide-span applications in masonry systems, wall thickness and height and dimensions of building components, such as lintels, bond beams and sample building-structure images, are provided.

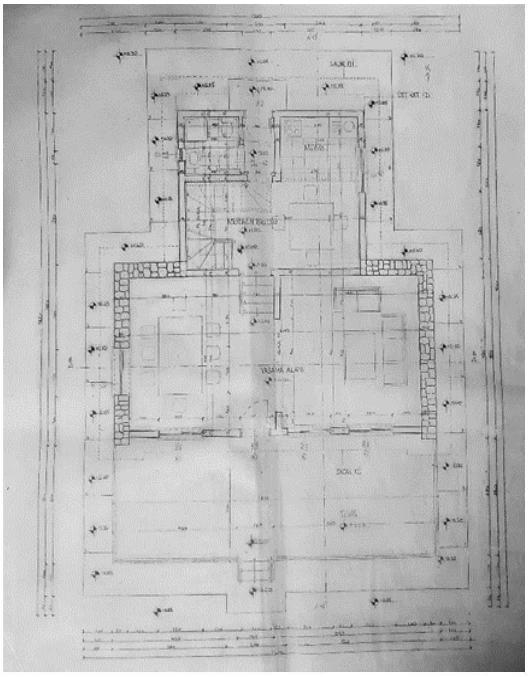
In the next step, the application phase, a plan chart is given in which they establish the structure-ground relationship, create contour plots, conduct land and building level analyses and construct the structural system. After students create their plan on the relevant diagram and solve the structural system, they transfer this knowledge to the third dimension with model-making.

Within the scope of this study, the main elements that students should pay attention to are:

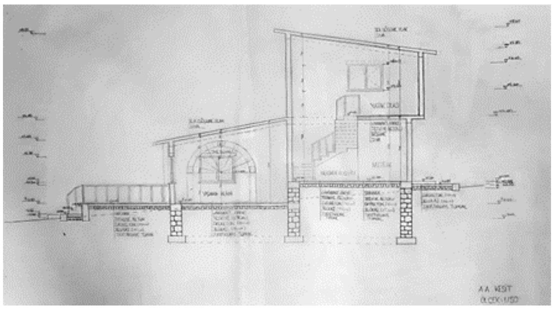
- The relationship between the natural ground and the building ground is correctly established,
- Building-environment relationship, approach to the building, producing solutions for the surfaces where the building comes into contact with the soil,
- Processing the ± 0.00 level into plans and sections by associating it with the natural land level,
- Processing of structural elements such as retaining wall, garden wall, railing that will be required after filling or excavation,
- How the building elements should transfer the load to the ground,
- The relationship between load-bearing walls, flooring and beams,
- Separation of load-bearing wall and partition wall,
- Correct use of building elements such as lintels, vaults, arches, etc., such as titles.
- Processing the architectural project (plan, section, appearance and foundation plan) by the technical drawing rules in 1/50 application project technique (such as internal-external dimensions, elevation, material information, pen thicknesses, etc.).

An essential element to be considered in masonry building systems is the transfer of slab load to the walls through bond beams. The students were expected to work on drawings and models based on their theoretical knowledge. Below are examples of applications given in different periods within the scope of the Building Science course, masonry systems. In selecting student projects, attention was paid to the various prominent features of the work.

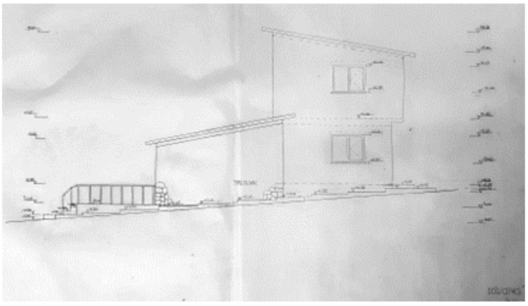
Model



Plan



Section



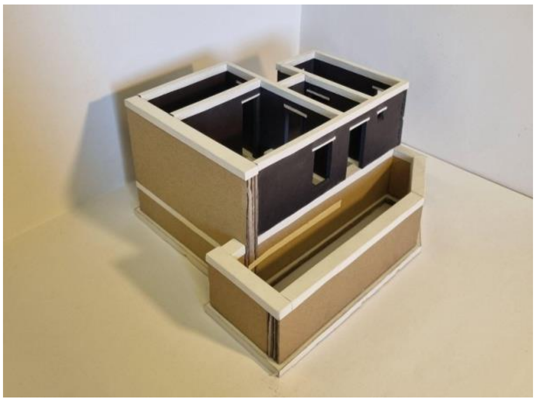
Elevation

Figure 2. Masonry System Practice-1 Visuals of Student Model and Drawings

Figure 2 presents the first student project prepared in this context as a model, plan, section, and view . Within the scope of the course, theoretical knowledge about stairs and roof systems is given at a basic level. The roof is drawn in sloping slab logic and the staircase is drawn in ground-based slab logic. For this reason, a detailed drawing of the roof and stairs in the interior was not expected from the students; it was considered sufficient to express it. However, the stairs on the ground are explained in detail under the topic of foundations and they were expected to draw this correctly in drawings. In addition, different materials were expressed using the scans in the drawings. The slope of the land was considered, a solution proposal was made and the elevations were processed in the relevant places. The basic information of the arch elements, such as the keystone, stirrup, center and radius of the arch, were shown correctly, as can be seen in the section;

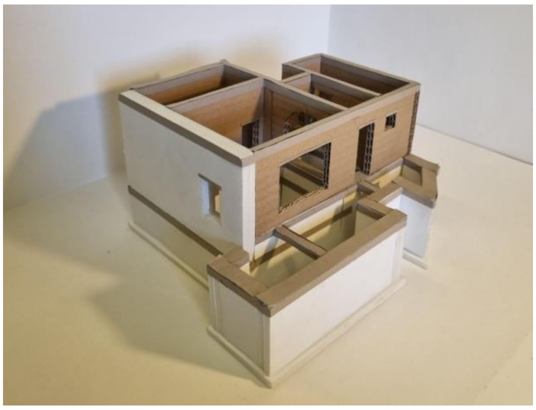
however, they were found to be incomplete because they were not expressed in the model. Therefore, the student conducted a study by the parameters given under the heading of the main elements to be considered.

Figure 3 shows two distinct student models with the same plan schema. In the model study, students were asked to demonstrate the structural components in particular. Using distinctive colors and texture elements to separate outstanding building elements such as beams and lintels is also preferable. The fundamental purpose here is to improve the decipherability of the building element in the model, thus raising awareness among the students.



Model-a

Model-a



Model-b

Model-b

Figure 3. Masonry System Practice-2 Visuals of Students Models

As seen in Figure 4, students were given an implementation regarding the aperture of the masonry system. The implementation has been an effective practice in which arches and lintel components are used in the span. In this way, solutions have been generated for the transfer of horizontal and vertical pressure loads. The theoretical information about the span of the central arch elements, like the keystone, springer, voussoir, impost, spring line, rise, center and radius of the arch, are elucidated. Therefore, it has been requested that this theoretical information be used correctly in the delivered technical drawings and models.


Model

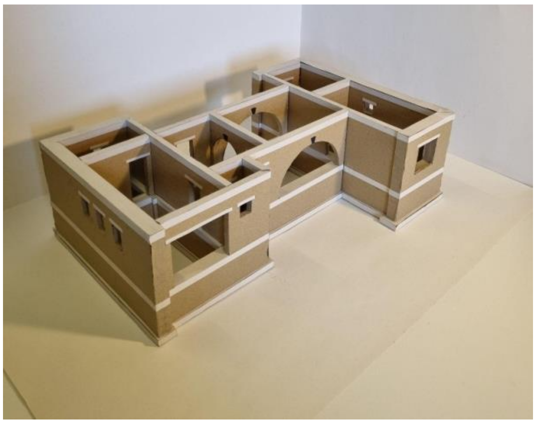
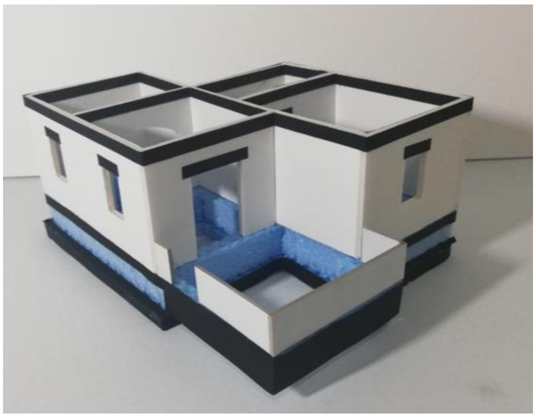
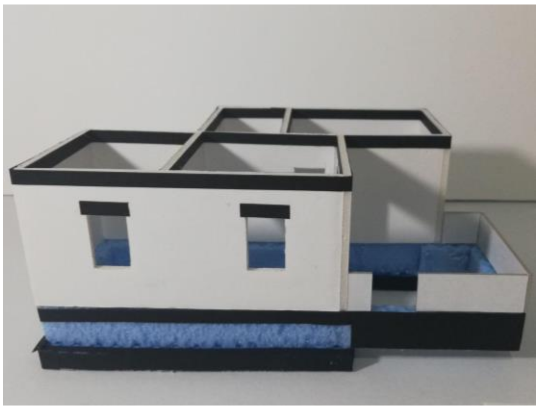
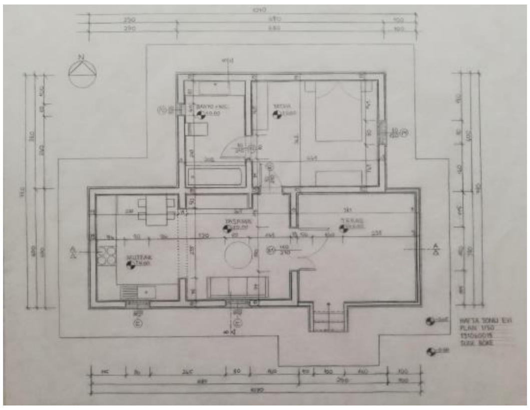

Model

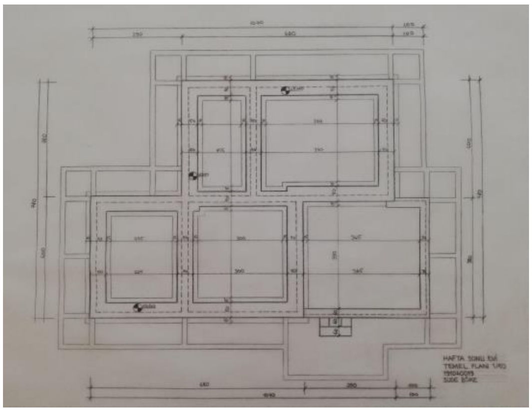
Figure 4. Masonry System Practice-3 Visuals of Student Model

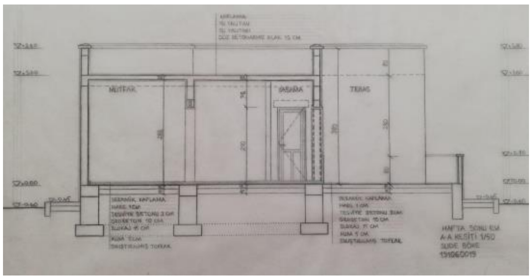
As seen in Figure 5, the model and drawing images of the practice and the project masonry system basic plan include the technical drawing. Students are required to submit the basic strategies and the plan, section and view of the whole study.


Model


Model


Plan


Foundation Plan


Section

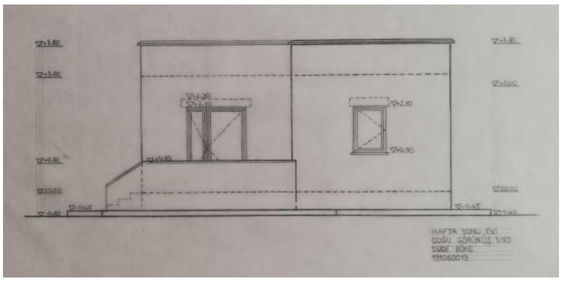
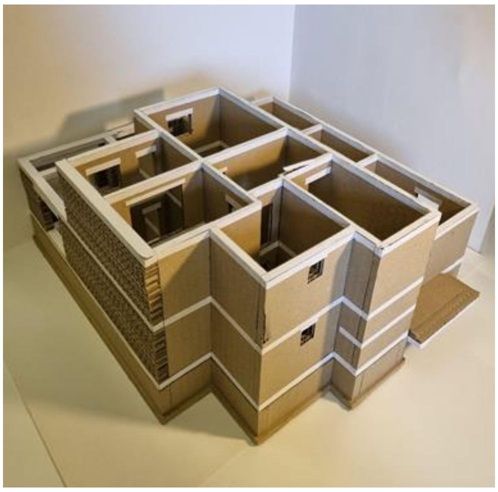

Elevation

Figure 5. Masonry System Practice-4 Student Visuals of Model and Drawings

Figure 6 exhibits several student model study examples with identical plan layouts. The difference between this model study and other studies is that it has more floors and is complicated. The students pointed out the stone or brick material division used on the wall with the differentiation in texture. Moreover, although the work was carried out on the same work schema, quite different studies were obtained in three-dimensional studies due to the flexible floor plans.


Model-a


Model-a


Model-b


Model-b

Figure 6. Masonry System Practice-5 Visuals of Students Models

3.2. Reinforced Concrete Frame Systems

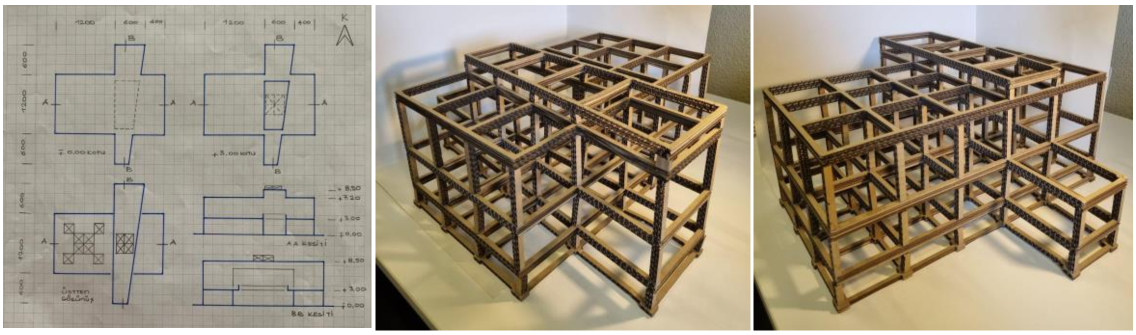
Theoretically, this title provides general information about reinforced concrete frame systems, requirements and Earthquake Regulations with reference. Subject content comprises the axis system, column-beam relations, minimum dimensions of structural components, foundation system and elements, shear walls, core position in the building, reinforcement elements and reinforced concrete structural systems/forms. Information is also given on what needs to be considered at the start of construction when creating an excavation site and on the safety of the shoring system created in the excavation site. Then, foundation types are comprehensively explained as surface foundations, deep foundations and their sub-titles. Ultimately, the theoretical part is clarified with sample practice images that refer to all these titles and subtitles.

In the practice stage, a plan schema is given for the involved subject. In practice, solutions are expected in which they will establish the structure-ground relationship, originate contour curves, land and building level analyses and construct the load-bearing system. The students, in practice, gradually produce the original plan setup on the scheme and solve the structural system, subsequently transferring this knowledge to the third dimension with model creation.

Within the scope of reinforced concrete frame systems subject, students are also expected to pay attention to the following items in addition to the items given in masonry systems:

- Fiction of the axis system
- Compliance of column placement with the axis system
- Relationship between columns, beams, slabs and foundations
- Determination of beam heights based on aperture
- Place organization

The plan schema, in which students are expected to present solutions in line with the theoretical information they have received about the reinforced concrete system, is shown in Figure 7. Within this scope, the original axis system and the plan's layout are expected to be determined and the relationship between column, beam, slab and foundation will be resolved appropriately. Thus, the primary approach of considering and solving architectural design decisions entirely with the knowledge of the load-bearing system given in theory is provided.



Plan Schema Model-a Model-b

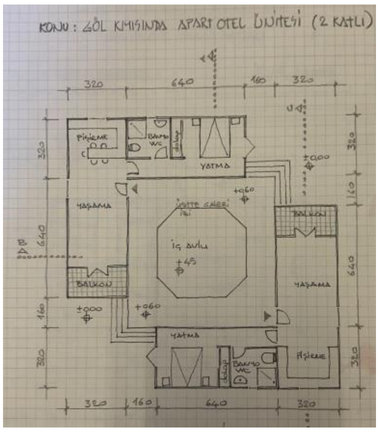
Figure 7. Reinforced Concrete Frame System Practice-6 Schema and Visuals of Student Model

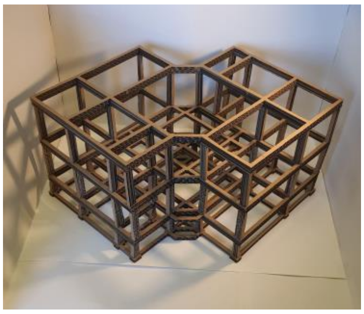
The two-story hotel structure with the reinforced concrete structural system was expected to be resolved on the diagram shown in Figure 8. As the diagram shows, two distinct L-shaped masses complement the inner courtyard.

Student work models and several plan and load-bearing system setup alternatives are observed. In the model, the L form and the inner courtyard were left in a more legible format and these two masses were connected with the beams and foundation system in the inner courtyard. In the plan design, the inner courtyard is entirely open.

In Mode-a, the inner courtyard was designed in line with the maximum opening values. The perception of two separate L forms was eliminated and the column beam and foundation system were constructed entirely. The plan design considered the inner courtyard more closed and the floors were evaluated as eaves.

The study's fundamental expectation was to manage the load-bearing system in the structure consisting of two masses, accurately determine the axis system, construct the column, beam and foundation relationship correctly and solve the level divisions in the inner courtyard.




Model-a


Model-a


Plan Schema Model-b Model-b

Figure 8. Reinforced Concrete Frame System Practice-7 Schema and Visuals of Students Models

3.3. Reinforced Concrete Slab Systems

In this section, reinforced concrete slab systems are lectured in the theoretical part under three main topics: slabs, beam slabs and beamless slabs. Course content subtitles, information on the application of reinforced concrete slabs, layout types according to reinforcement direction and plan form, slab types according to the way of sitting on supports, cantilever slab, load transfer information of slabs belonging to different building systems, the relationship between the span and thickness of the slab, the correlation between span and slab type (beamed and beamless), are precast systems. Within the scope of floor positioning on the ground, floor properties, drainage, flooring layer materials, application forms, thicknesses and heat-water-humidity insulation details are explained. Within the scope of beamed floors, ribbed (unidirectional), cassette (double-sided) and blocky (hollow-filled) slab types, building component measurement information, load transfer patterns, reinforcement usage and application details of these slabs are given. Finally, within the scope of non-beam slabs, in situ casting (mushroom and slab flooring), precast (precast) flooring, shell flooring, load transfer patterns, reinforcement usage and application details of these floorings are explained.

In the application stage of the course, students are asked to reconstruct the load-bearing system so that it will pass a wide aperture based on the planning scheme given in the reinforced concrete frame system. In other words, students are required to create wide apertures and gallery spaces as design limitations. Moreover, students must suggest one of the beamed flooring types per the plan layout. After these stages, students create their plan on the relevant diagram and solve the structural system, then transfer this knowledge to the third dimension with model building.

Regarding reinforced concrete flooring systems, they are expected to pay attention to the items given in reinforced concrete frame systems and the following items:

- Reconfiguring the axis system to accommodate wide spans,
- Determining beam heights based on the span,
- Ensuring equal division of beam spacing in the selected beam-supported floor type,
- Establishing the relationship between columns, beams, slab and foundation,
- Deciding on the beam-supported floor type based on wide apertures and plan configuration.

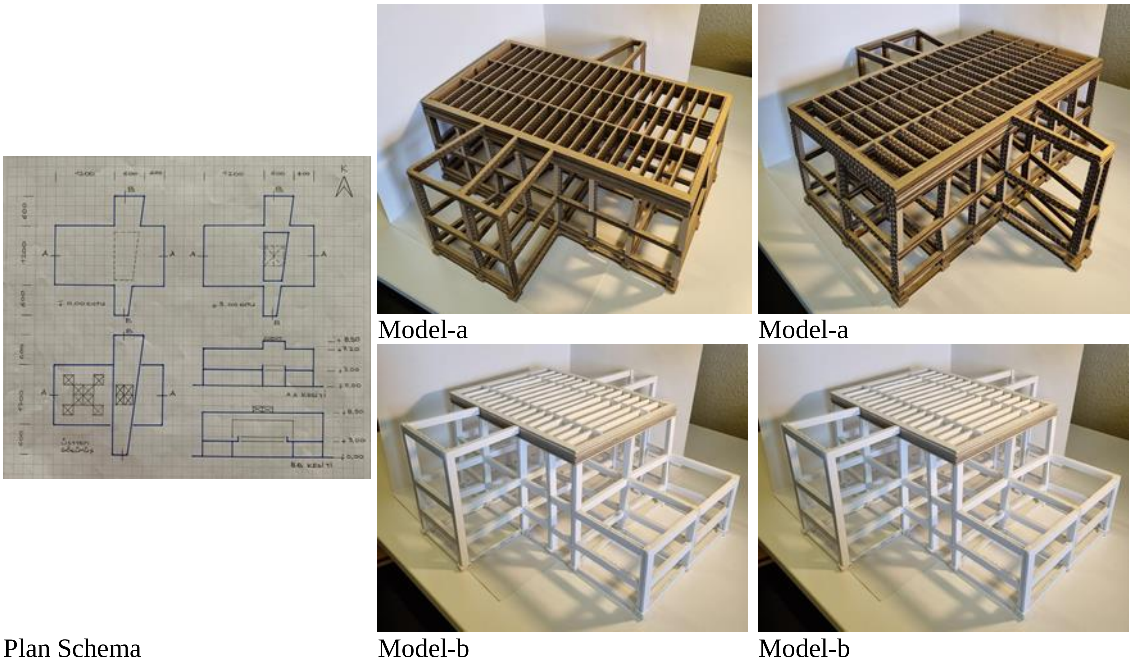


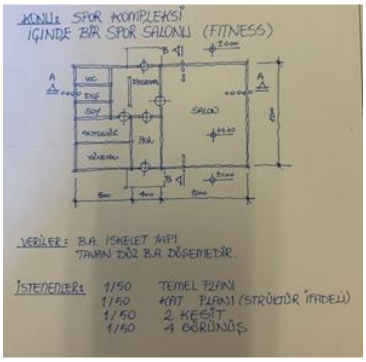
Figure 9. Reinforced Concrete Slab System Practice-8 Schema and Visuals of Students Models

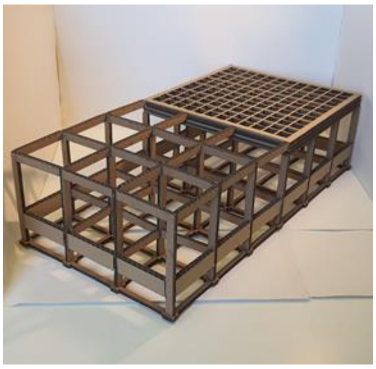
The reinforced concrete frame system diagram is shown in Figure 6. A wide aperture was passed over this skeleton system with the one-way rib flooring system. In Figure 9, the work of two different students is seen as Model-a and Model-b. The slab solutions, which are determined as the clean aperture transition form aimed to be created in the study, are aimed to establish the correct correlation with the column beam system of the building. In determining the load-bearing system, decisions such as axis system, column location and dimensions, interior setup, gallery space in the interior, location of circulation elements and indoor and outdoor use preferences were made through models and drawings, considering them as a whole.

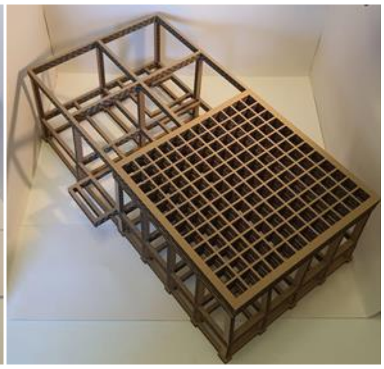
A sports complex building was carried out in which they could use the data on the solutions of reinforced concrete flooring systems, whose theoretical information was given with the scheme in Figure 10. The class was divided into two groups and various flooring solutions were requested on the same building according to the apertures created in the plan layout. It was expected to provide a wide span by crossing wide openings from one part of the classroom with cassette flooring and from the other part with a ribbed flooring system. As seen in the models, different axis system constructions were constructed. Therefore, students were provided with originality in the design approach to the interior space arrangement.

In ribbed and cassette ceiling systems, students were expected to elaborate on the minimum and maximum values, the thickness and height of the beam elements, the arrangement of the system at equal intervals and the correlation of the flooring system with the columns and beams at the external boundaries of the building. Moreover, considerable points, such as the foundation setup and the relationship between the varied flooring system solutions in the building, have been the points considered in these studies.

After creating the axis and column layout, the arrangement of the flooring system at identical intervals was emphasized. It was explained that floor beam heights can usually be accepted as L/10 for rib flooring and L/12 for cassette flooring.





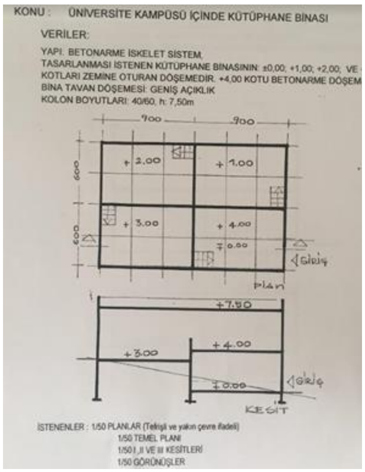


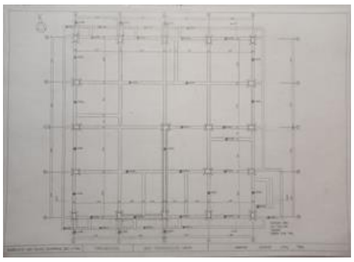
Model-a Model-a

Plan Schema Model-b Model-b

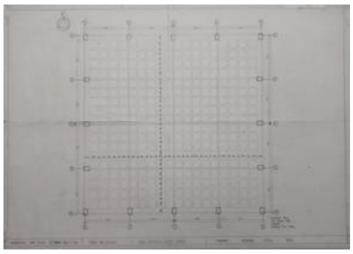
Figure 10. Reinforced Concrete Slab System Practice-9 Schema and Visuals of Students Models

Figure 11 shows the diagram, student drawings and models of Practice 10 given in line with the subject. Unlike other applications, students were expected to come up with solutions on the facade surfaces of the building, which come into contact with the soil due to the slope of the land. In this direction, load-bearing wall studies were carried out.

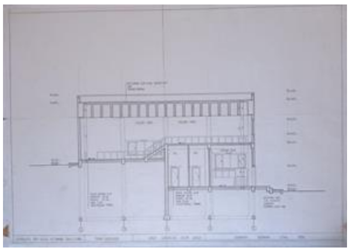


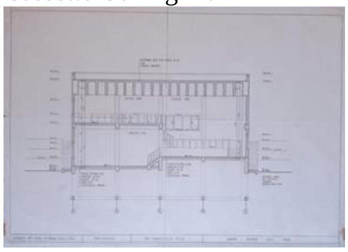


Foundation Plan



Cassette Ceiling Plan

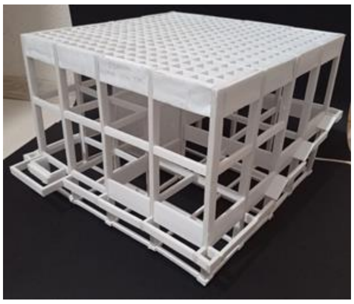


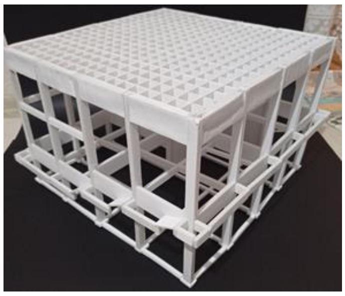


Plan Schema

Section

Section





Model

Model

Model

Figure 11. Reinforced Concrete Slab System Practice-10 Schema, Visuals of Student Drawings and Model

3.4. Wooden Systems

Theoretically, under this title, general information about reinforced concrete frame systems, reinforced concrete frame system requirements and Earthquake Regulations are given with reference.

Theoretically, this topic explains traditional systems (with wall structural), Central European Systems, Traditional Turkish House Systems, American Western Systems (Platform), American Balloon Frame Systems, strut beam systems and prefabricated panel systems. In the content of these titles, single base - double bottom wooden frame system, definition of the elements used in the wooden skeleton system, connection methods of wooden elements, wood flooring construction techniques, different construction elements of wood such as steel and reinforced concrete and connection details are expressed. In addition, methods such as the relationship of wooden elements with the ground and moisture, the creation of wall floor and roof surfaces in the wooden frame system, the leading intermediate beam relations and the dimensions of the beam openings, the use of joint sections and buttresses to pass large spans, as well as methods of cantilever formation and gallery space are explained. At the end of the theoretical explanation, sample building images refer to all subtitles.

After expressing a standard plan scheme, students must specify the load-bearing axes with their unique approaches. Subsequently, they are expected to solve the load-bearing system most correctly by the axes. After the fundamental design decisions are made, the form of the building is shaped with a model. This distinguishes the wooden frame system from other applications. Although beginning from a similar plan scheme with this method, in the third dimension, building designs with wooden frame systems in somewhat different forms are expected from each student. Moreover, students are given secondary design restrictions such as wide apertures and forming galleries. It is aimed to reinforce the subjects, such as creating a combined cross-section beam, buttress and cantilever, which increases the section in the main beam, which is theoretically explained. Moreover, it is aimed to reinforce topics such as creating a combined section beam, buttress and cantilever, which increases the section in the main beam, which is theoretically explained. Students are expected to pay attention to the following elements, as well as the items given in masonry and reinforced concrete frame systems within the scope of wooden systems:

- Placement of wooden struts and dividing the intermediate wooden struts for cladding at equal intervals,
- Connection relationship of stud, main beam, intermediate beam and floor beams
- Correct utilization of methods for passing wide span
- Floor beams being placed in the short direction according to the span,
- Formation of the roof decking in the appropriate direction according to the slope and verge detail,
- Correctly drawn external wall and roof insulation,
- Properly designed details for the connection between wood, reinforced concrete and the ground,
- Detail solution for the connection floor and the wooden timber floor,
- Subdivision of floor beam spacings equally,
- Creation of window and door openings.

Figure 12 shows images of four different student models belonging to the "art gallery" application work, on which the ground floor plan scheme is given. The expected axes are determined first in the implementation part of wooden frame systems. Subsequently, a sketch study and model and structure design are carried out to create the plan setup of the project, respectively. As shown in Figure 12, the ground floor plan scheme is the same, but the works that differ in the third dimension are seen with the overhangs and roof designs on the upper floor. With this practice, students discover how to cross the wide aperture, create the console, correctly establish the connection between the floor beam, the main beam and the intermediate beam and solve the mezzanine and roof floor with the proper structural decisions with model work.

According to the planning scheme in Figure 13, the timber frame system should be designed correctly and the masonry stone wall and the timber bearing system should be designed and analyzed together. In addition, the reinforced concrete slab and the wooden floor resting on the ground should be finished at the same level. Different designs should be designed on the roof. Finally, semi-open areas with or without pergolas should be created. The outcome obtained from the student models is that the learning-by-doing method enhanced the theoretical information explained during the term.

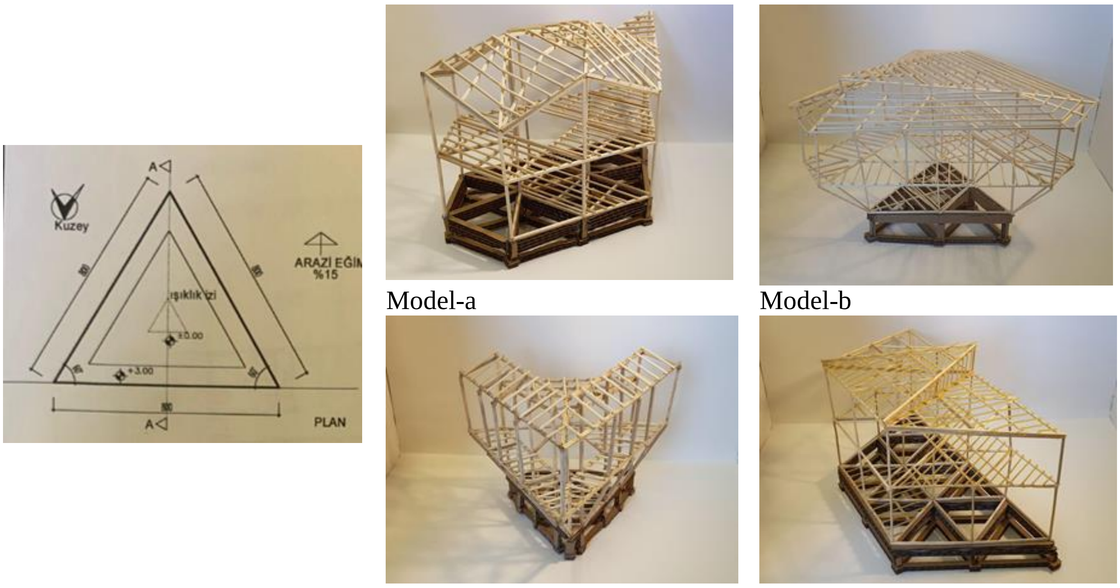


Figure 12. Wooden Frame System Practice-11 Schema and Visuals of Students Models

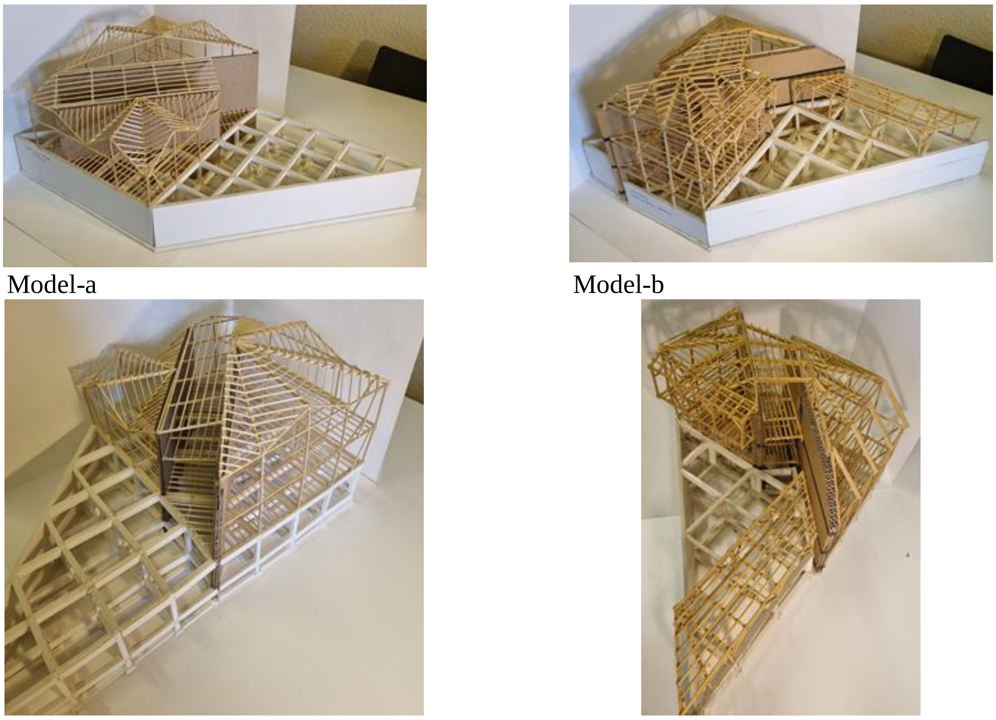
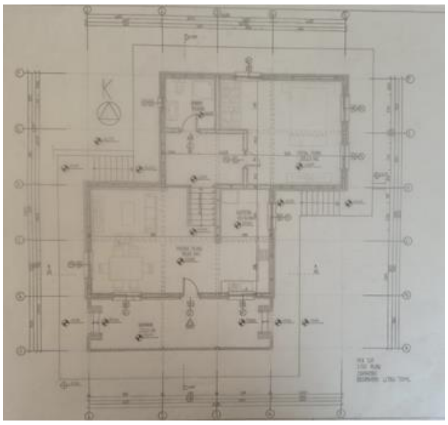
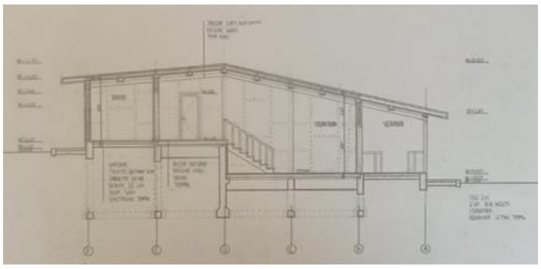


Figure 13. Wooden Frame System Practice-12 Visuals of Students Models

Two distinct student models and drawings of the "Summer House" application study, which is an alternative homework given within the scope of the wooden load-bearing system, are shown in Figures 14 and 15. Within the scope of the study, the structure-environment correlation was considered. To address a solution to the sloping land problem, the building was planned to sit at different elevations, and structural elements such as load-bearing walls and retaining walls were used in the external areas in contact with the soil.


Model


Plan


Section

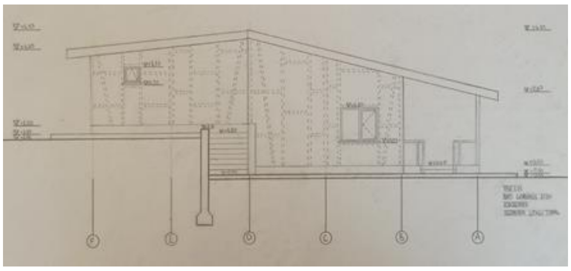
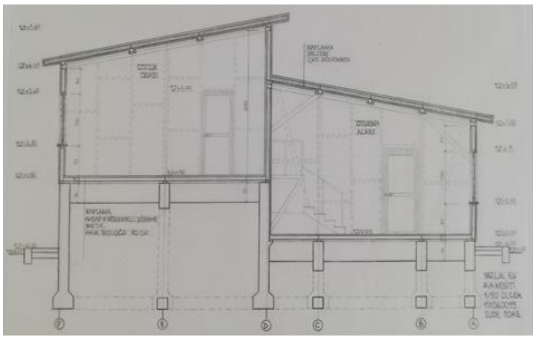

Section

Figure 14. Wooden Frame System Practice-13 Visuals of Student Drawings and Model


Model


Model


Section

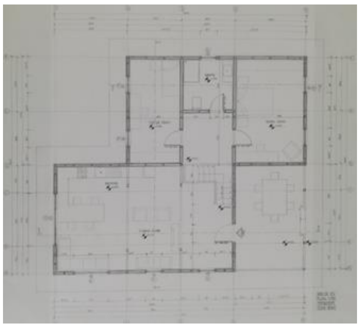
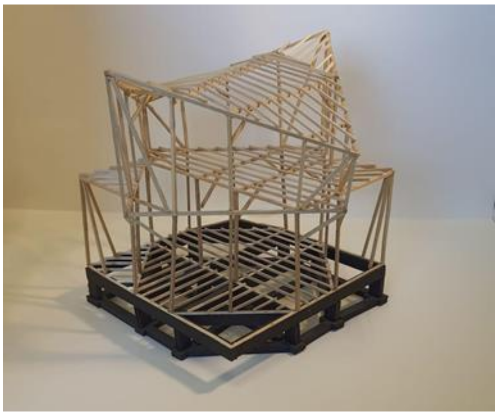

Plan

Figure 15. Wooden Frame System Practice-14 Visuals of Student Drawings and Model

Technical drawing rules process plans, sections and views. By this means, it is seen that the intelligibility of the load-bearing system is at a sufficient level. Similarly, in these two examples, the same plan scheme has been solved with roof systems with different elevations and slopes.


Model-a

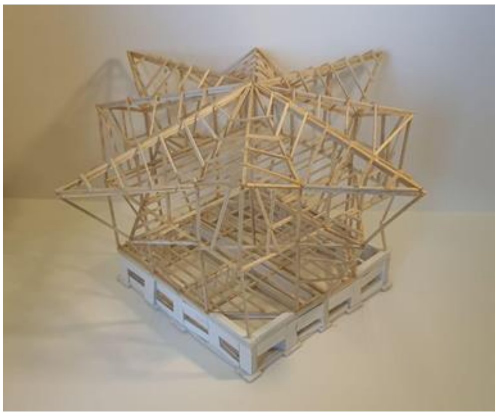
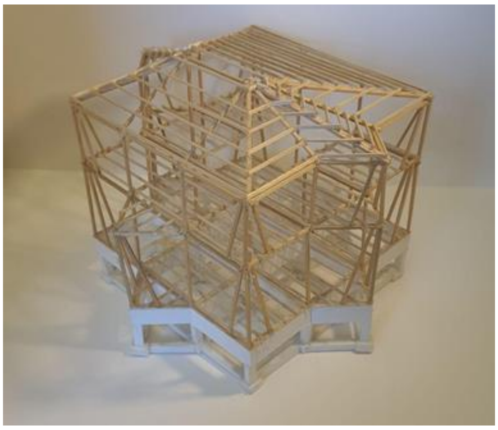

Model-b

Figure 16. Wooden Frame System Practice-15 Visuals of Students Models


Model-a

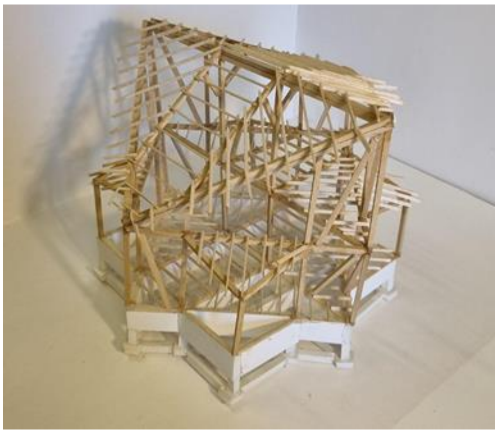
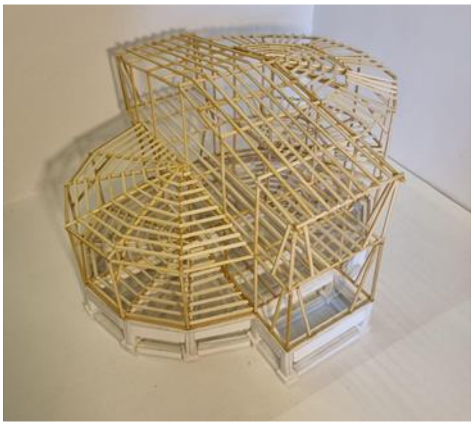

Model-b

Figure 17. Wooden Frame System Practice-16 Visuals of Students Models


Model-a

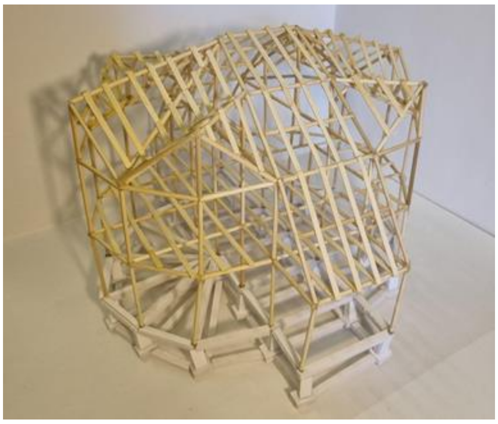

Model-b

Figure 18. Wooden Frame System Practice-17 Visuals of Students Models

Examples of wooden models are shown in Figure 16-18, an example of form designs that differ in the third dimension based on a similar plan scheme. These differences are provided by structural elements such as cantilever overhangs, buttresses, eaves and roof slopes at different angles. In addition, in all the examples of the wooden structural system examined, the students met the expectations, such as creating a combined section to pass wide apertures, using buttresses and creating a gallery space.

4. Findings

Teaching the "Building Science in Architecture" course using the active learning method at Gazi University Department of Architecture undergraduate education was examined under five main topics covered within the course. In Table 1, the contribution levels of the general achievements expected to be obtained at the end of the course are determined for each main heading.

The level of contribution of each main heading to general achievements: Very low (1), low (2), medium (3), high (4) and very high (5). The course instructors determined the contribution level for each main heading using the participant observation technique based on their in-class observations and experiences throughout the semester and the evaluation of the final products delivered at the end of the semester.

The general achievements in Table 1 enable students to develop during the building knowledge course and increase their ability to apply their technical knowledge and skills in the advanced stages of architectural education. In this sense, evaluating the contribution levels of the five main topics learned within the scope of the course is also essential in evaluating the effectiveness of the active learning method.

It is essential to teach the general knowledge of architecture and building science education by technical terminology for students to start practicing. The instructors' observations and experiences during the semester effectively determined the contribution level to this general achievement. It is seen that the contribution level of the reinforced concrete skeleton system to the general achievement is the highest in transferring the theoretical building knowledge subjects to the application stage, understanding the problem, and producing alternative solutions. The reason for this situation is thought to be that the student can make observations in his/her daily life due to the use of reinforced concrete frame systems in the construction sector in Turkey. This situation effectively provided more efficient coordination between two-dimensional and three-dimensional thinking for the reinforced concrete frame system. It solved the problem with two-dimensional and three-dimensional association skills. When the general achievements of the Reinforced Concrete Floor Systems are analyzed from the table, it is seen that this situation could be more effective. It is seen that the correct construction of cassette and rib beams in the subject of slabs has developed as a result of the interactive work of the course instructors and students; this subject has been reinforced with model studies.

When the general achievements on the subject of masonry system (Masonry system) are examined, it is seen that the students who receive theoretical knowledge remain at a more intermediate level in solving the given problem. In this subject, it is seen that the structural system of the plan diagram given in the course can be constructed with the theoretical knowledge they receive. However, solving the structural elements such as arches, vaults and the foundation system is complex. Through in-class interactive studies, drawings and models, it is seen that these difficulties were understood at the end of the course and correct solutions were brought to the given problem. In this subject, while solving the structural system, it is expected to find solutions in the parts where the stone and brick-bearing walls meet. This situation effectively acquires the general outcome of perceiving the relationship between materials.

Table 1. Student General Achievements in Building Science Course

	Student General Achievements in Building Science Course	Masonry System	Reinforced Concrete Frame Systems	Reinforced Concrete Slab Systems	Wooden Systems
1	Teaching basic information by the technical terminology of architecture and building science education	5	5	5	5
2	To be able to practice the elementary level making knowledge subjects learned in theory	4	5	5	3
3	Developing the ability to understand the given problem and produce alternative solutions	3	4	3	2
4	Coordination between two-dimensional and three-dimensional thinking	4	4	4	3
5	To be able to solve problems by thinking both two-dimensionally and three-dimensionally and associating them with each other	3	4	3	2
6	Ability to use limited working time effectively	3	3	3	1
7	Ability to produce solutions in a limited time (for sketching exam and course process)	2	3	2	1
8	Obtaining basic information about materials used in structural systems	5	5	5	5
9	To be able to perceive the relationships between materials used in structural systems	3	4	4	3
10	To be able to perceive the relations between the building elements	3	4	4	2
11	Developing awareness of differences and similarities between structural materials and systems	2	4	3	2
	Contribution Level: 1: Very Low 2: Low 3: Medium 4: High 5: Very High				

The wooden skeleton system is the most challenging subject in the general achievements table. This subject becomes more comprehensible with the interactive work of the students with their instructors in the classroom and model work after the theoretical knowledge. Before starting the model, students are expected to cut their materials per the dimensions of the wood and solve the carrier system by the dimensions of the material they have. The reflection of this situation on the general achievement is seen in acquiring knowledge about the material used in the building system. In the wooden carrier system, designs that will create different facade effects in the given draft scheme and the solution of the appropriate carrier system are provided to understand the given problem and produce alternative solutions.

When the general gains of the main topics of the building knowledge course are analyzed through the table, it is revealed that although the general gain of the theoretical knowledge taught with the traditional method is very high, this effect varies from low to high in subject specificity. It is seen that the high impact is on subjects that students have the chance to experience in their daily lives. It is seen that the active learning method, which is based on the interaction of the student with the instructor in the classroom and the simultaneous execution of 2D technical drawings and 3D models, is effective in the success of the application of the subject whose theoretical knowledge is given.

5. Conclusion

This study emphasizes the importance of effective teaching of the building science course, which is one of the essential components of architectural education, with active learning methods. Architecture students need a robust basis for building science to succeed professionally and graduate with knowledge. For this reason, it is pointed out that the building science course plays a critical role in developing students' design skills, structural analysis abilities and technical solution generation capacity.

Architectural education allows students to develop their analytical perspective skills and actively participate in the design process. Active learning methods encourage students to take an active part in the process of solving design problems rather than passively receiving information. Thus, students can gain a deeper understanding of structural issues, develop creative solutions to complex design problems and effectively manage technical confinements in design.

Within the scope of this study, students interacted with their executive lecturer on topics such as masonry systems, reinforced concrete frame systems, floors and wooden systems in the building science course content. It is seen that they actively participate in the learning process by making designs, drawings and model applications related to the topics explained. Theoretical knowledge of these four main subjects learned within the scope of the course is given through traditional learning methods such as presentation and expression. It has been observed that the active learning method effectively understands the given problem and produces alternative solutions by simultaneously carrying out 2D drawing and 3D model work during the application phase of the building science topics given in theory.

During model work, students put building science into practice by paying attention to details and using scales correctly. This process allows students to evaluate architectural projects more realistically by improving their thinking about architectural spaces in three dimensions. Moreover, while making models, students learn to use different materials, gain practical knowledge and experience about construction techniques, discover application techniques and experience assembling building elements. This enables students to gain a deeper understanding of issues related to structural design.

As a result, teaching the building science course with active learning methods in architectural education is essential for students to be successful in architectural practice. This approach enables students to understand structural issues, develop design skills, and transform technical knowledge into practical applications. Therefore, the adoption of active learning methods in architectural education programs and the effective implementation of the building knowledge course will support students to grow up as more equipped, creative and conscious architects. In future studies, the impact of the competencies acquired from the building course on the professional development and careers of two groups of students who learned the building science course with the active and traditional learning methods can be measured and comparatively analyzed with a survey study.

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