Grafting Construction Thinking: An Action-Based Approach to Construction Course Redevelopment

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CHAPTER II

Construction courses are essential to architectural education since they equip students with the knowledge to realize their design ideas. However, learning and appropriating construction knowledge in design thinking are challenging for many architecture students, as the authors have witnessed this hardship in their teaching practice in Turkey. Consequently, this study aimed to develop the hypothesis that an 'experiential facilitation approach,' which employs and crosses back and forth among multiple senses, modes, and scales of engagement with knowledge, including full-scale building, has the potential to increase the reception of construction knowledge. To evaluate their hypothesis, the authors have designed action research that tracks, measures, and reflects on the effects of these multiple methods, scales, media, and tools through first-hand observation, short surveys, semi-structured in-depth interview questions, and reflection on course outputs. The outcomes show how students come to terms with construction knowledge as an embodied experience. The research outcome contributes to the teaching of construction courses in architecture schools in general.

Introduction

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Technology-based courses are essential to architectural education as they equip students with practical knowledge to actualize design ideas. They not only prepare students to move into practice as more equipped with technical knowledge but also increase their creative genius and expand their insight into the poetics of building (Rinke, 2019). 'Technology' comes from the Greek word techne, which denotes knowledge achieved through making or production (Heidegger, 1977). It refers to both arts and crafts. Technology is applied knowledge, and due to its engagement with natural laws, i.e., imitation of physis, its creative role may become forgotten.

As our contemporary period highlights the socio-political role of architecture and emphasizes the role of architects as agents of social change, there is diminished visibility of the inherent significance of technology-based knowledge that allows generating building and the poetic character and tectonic language of architecture. Whereas in some architecture schools, technology-based courses are closely related to design studios and inform design thinking more efficiently, they remain more adjacent or secondary in other architectural curricula. While appropriating structure and construction knowledge in design thinking can be a challenge in many cases (Voyatzaki, 2002; Schwartz, 2015), recent studies point out a lack of interest in construction courses and disconnection between design studios and construction courses in architecture programs (Masri, 2017; Rauf & Shareef, 2019). Carpenter (1987, p. xi) noted the criticism that pointed to "students' inability to deal with pragmatic things." Today, there is still a growing amount of complaints about the lack of knowledge of recent graduates to detail buildings for realization (Wood, 2006).

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The authors of this chapter teach construction courses at the Department of Architecture at Yeditepe University, where the changes in its architecture curriculum in 2019 reflected a reduction of the weight of technology-based courses in the curriculum. Before Aktuna joined the department, construction courses used to follow a teaching model after the Beaux-Arts, which depended on a drafting-centered practice approach common in architectural schools in Turkey. Despite the crucial dependence of building on construction drawings (Ridgway, 2009), drafting as a learning tool has shortcomings. Various scholars investigated the newer methods of teaching construction courses to improve construction courses in architectural education in Turkey. They have proposed the incorporation of three-dimensional physical models to establish a more concrete bridge between drawings and reality (Diri & Mayuk, 2019; Bodur et al., 2020; Kavraz, 2021); Gür & Yüncü (2010) proposed engagement with real-scale works to solidify the connection between theoretical and practical knowledge; and Agırbas (2020) experimented with the use of digital technologies in construction courses.

As the authors have taught construction courses at Yeditepe University (Karahan since 2008 and Aktuna since 2021), they have observed that the connection between a building and its representation in working drawings is hard for many architecture students and poses a fundamental barrier to accessing and applying construction knowledge in design thinking. Due to the challenge for most students to grasp construction knowledge as practiced in construction drawings, which further posed a barrier to engaging with construction knowledge and incorporating tectonic language into design work, the authors planned to redevelop the construction courses. Having witnessed the students' struggle, the authors developed the following hypothesis: an 'experiential facilitation approach,' which employs and crosses back and forth among multiple senses, modes, and scales of engagement with construction knowledge, has the potential to facilitate construction thinking and representation. To evaluate their hypothesis, the authors devised action research to engage students with construction knowledge through multiple instruction methods, tools, and scales and to observe how students respond. The study compares the course outputs with those of previous semesters for course redevelopment while retrieving the experiential themes of construction learning.

This chapter consists of seven parts. After this 'Introduction,' the second part reviews the approaches to teaching construction courses in Turkey and compares them with the context of the action-based study; the third part introduces the theoretical background of the research; the fourth part presents the research methodology; the fifth and sixth parts consider the results and discuss the main contributions of this study, which leads to the 'Conclusion.'

2. The Teaching of Construction in Architectural Schools in Turkey and the Case of Yeditepe University

This part reviews the literature on the teaching of construction in architectural schools in Turkey and the methods used to instruct construction knowledge. Through a review of the universities' websites, it compares the construction courses' place and scope in the architectural schools' curriculum of three prominent state schools (Middle East Technical University, Istanbul Technical University, and Mimar Sinan Güzel Sanatlar University) with Yeditepe University. It further examines the potential contribution of the applied course hours.

The Department of Architecture of METU has three mandatory construction courses and five construction-related courses. The 'ARCH 259: Building Construction Technologies' course takes place in the third semester with two theory and two practice hours. It covers the examination of the structural components that make up the construction system of a building in wood, steel, reinforced concrete, and composite building systems. The practice involves architectural drawings, field trips, and seminars. 'ARCH 351: Building Detail Modelling' is in the fifth semester with two theory hours and four practice hours. The course covers orthogonal architectural representation for architectural projects, theory, techniques, methodologies, tools for architectural detailing, and the advantages and disadvantages of different approaches to architectural representation. The application hours entail drawings and models. The 'ARCH 453: Construction Design Practice,' a fourth-year course, entails three theory hours and two practice hours. It covers systems, system details, and performance considerations of a building and entails writing specifications in addition to producing construction drawings and models.

The Department of Architecture of ITU has three mandatory construction courses and ten construction-related courses, including elective courses. 'MIM 203: Building and Construction in Architecture' takes place in the third semester with three theory hours and one practice hour. It introduces the concepts of architectural and construction technology, systems approach, building elements, building and construction methods, user-environment-building system interaction, wall and partition systems, window and door systems, flooring systems, vertical circulation systems, and roof systems. Application hours entail full-scale models, analysis, and synthesis. 'MIM 204: Architectural Building Element Design' takes place in the fourth semester with three theory and two practice hours.

It introduces the analysis, design, and integration of building elements according to defined criteria and boundaries, wall and partition systems, window and door systems, flooring systems, vertical circulation systems, roof systems, outer shell, and the mutual interaction of design and structural elements. Application hours include two-dimensional technical drawings and three-dimensional digital models. The 'MIM 484: Construction Project' course takes place in the seventh semester with two theory hours and six practice hours. It includes material selection in the context of a comprehensive building design, construction techniques, environmental control systems selection, and design, arrangement of the carrier system, design stages according to the current building legislation, integration, and coordination of building subsystems with other building components, explanation of each design stage, project design following national and international project regulation principles. Application hours contain drafting.

The Department of Architecture of MSGSU has four mandatory construction courses and twelve construction-related courses, including elective courses. 'MIM 108: Construction 1' is in the second semester, with two theory hours and three practice hours. 'Construction 1' covered the general rules of masonry and reinforced concrete frame construction, building elements, the earthquake-resistant structure design, foundations, flooring, walls, and roofs. 'MIM 207: Construction 2' occurs in the third semester with two theory hours and four practice hours. 'Construction 2' covers wood and steel skeleton construction, reinforced concrete, wood, and steel staircase organizations and roofs. Application hours entail two-dimensional technical drawings and physical models (Diri & Mayuk, 2019). The 'MIM 205: Architectural Application Project 1' course takes place in the third semester with three theory hours and two practice hours. The 'MIM 206: Architectural Application Project 2' course has three theory hours and three practice hours in the fourth semester. The course description states that the student learns the architectural design process from the preparatory and preliminary research studies to the environmental and site plan studies, the idea project, the preliminary project, and the final project, in the detail-whole relationship, through analytical thinking, synthesis, evaluation, problem-solving, developing technical and graphic expression skills, and the course brings design awareness to the students. In 'Architectural Application Project 1,' the students design a structure. In 'Architectural Application Project 2,' the students prepare the application project of the designed structure. Application hours entail two-dimensional technical drawings and three-dimensional models.

In architecture schools in Turkey, construction education mainly consists of two parts. The instructor gives theoretical knowledge; in the second part, students apply this knowledge, mainly by drawing. Methods such as seminars, laboratory studies, and examination of samples are also used during class hours (Yücel, 2018). The traditional approach starts with the instructor's presentation and demonstration of theoretical knowledge in the lectures and the students watching and listening to the lecture. At this stage, the student takes a passive role, and the instructor takes an active role. Although construction courses mainly depend on applying construction knowledge through technical drawings, they also include modeling. In this regard, the literature contains studies conducted at the Architecture Department of MSGSU (Diri & Mayuk, 2019), OMU (Bodur et al., 2020), GTU (Mayuk & Cosgun, 2020), and KTU (Kavraz, 2021).

The Architecture Department of YU has two mandatory construction courses and six construction-related courses, including elective courses. The 'Construction' course currently takes place in the second semester, with two theory hours and two practice hours, and includes the general rules of the reinforced concrete frame structure and an introduction to building elements from the foundation to the roof. The 'Construction Project' is in the sixth semester with two theory hours and three practice hours. Besides the rules for preparing the application project, the course contains the construction of timber and steel frame structures, wooden and steel stairs, and roofing. In both courses, the practice entailed drafting before the intervention through action research.

Table 1. The weight and methods of construction courses in several leading universities compared to Yeditepe University (Developed by the Authors).

	Construction Courses	*Weekly Hours (T+P)*	*Application Methods*
METU	Building Construction Technologies Building Detail Modelling Construction Design Practice	2+2 2+4 3+2	Drawings Drawings and digital models Drawings and models
ITU	Building and Construction in Architecture Architectural Building Element Design Construction Project	3+1 3+2 2+6	Full-scale models Drawings and digital models Drawings
MSGSU	Construction 1 Construction 2 Architectural Application Project 1 Architectural Application Project 2	2+3 2+4 3+2 3+3	Drawings and physical models Drawings and physical models Drawings and models Drawings and models
Yeditepe University	Construction Construction Project	2+2 2+3	Drawings Drawings

Compared with some of the leading architecture programs above, the construction courses have less weight in the architecture curriculum of YU, and the 'Construction' course takes place sooner in the program. The fewer hours dedicated to construction courses in the curriculum lead to the intensification of content while students need help connecting theoretical and practical knowledge when the application depends on the representational realm of technical drawing, especially for first-year students. When technical drawing is both a learning and still a learned tool, it introduces a paradox. It raises the need for other means of access to construction knowledge. Consequently, the authors turned to the idea of an 'experiential facilitation approach' by merging ontology and representation of building—as explained below.

3. Splitting and Merging of Design/Construction in Architectural Education/Practice

The dominance of technical drawing in architectural education follows the split between design and construction and ontology and representation. Today, in both education and professional practice, architectural work is designed and fully developed in a representative environment. The application follows after the design. This split puts a great distance between the designer and the construct. In design studios, the phrase application follows the language of modeling software, in which the designer applies structure and materials to the surfaces of their already formed projects. Models based on combining many surfaces lack depth, sensuality, or structural logic.

Carpenter (1987, p. x) highlighted this distance between design and construction and the architect and construction site that starts in architectural education and continues in professional practice: "In school we are taught that the architect must observe construction. The architect works in another place, usually at a distance from the building activity, and sends messages—plans, drawings, and specifications—to the site." In history, Leon Battista Alberti was the first person in architecture to separate the intellectual task of design from the craftsmanship of construction. In this view, which has been developing for centuries, with the distinction of mind and hand—besides discourse—surface, ornamentation, and image became the architect's task (Moravánszky, 2018). The separation of design and construction processes, the hindrance of the difference between entities and their representations, and the spread of a surface-oriented thinking process are important topics of contemporary criticism. While Frampton argues for attention to the difference between ontological and representational, he also underlines that architecture is an abstract discourse based on surface, volume, and plan after an existing building (Frampton, 1995).

The ontology of the work requires a deep understanding of the material and structural system that never leaves its symbolic or phenomenal meaning (ibid).

With the development of tectonics, a stance that aims to reunite design and construction thinking has developed in architectural education again. The distance between design (in a representational realm) and construction (as application or realization) in architectural pedagogy has been overcome in the 'design/build' approach in recent decades. Design-build is an umbrella term with applications ranging from industry to education. It is a project delivery method in the industry. Unlike the traditional three-part structure consisting of employers, architects, and contractors, in the design-build method, the team works under a single contract as a single stakeholder to provide design and construction services to the project owner (Canizaro, 2012). Design-build is an alternative pedagogical approach to architectural education, which happens in a theoretical, desk-based, and tool-driven design process with drawings, models, and digital models common to design schools (ibid). In the design/build approach, design and construction, actual and representation, and theory and practice merge.

While design/build in architectural education developed in Britain and USA for community service (Canizaro, 2012; Hailey, 2016), its scope is beyond community service. Design/build pedagogy goes beyond comprehension and allows for innovation by engaging with materials, methods, and the tectonic language of buildings. Weber suggests the potential of building to bridge form, materials, and methods. Weber (2018, p. 2) notes, "Design build can be a pedagogical tool that teaches students to slow down and value the materials and methods of building as the carriers of architectural meaning." Design/build pedagogy merges ontology and representation in work—work as a site, process, practice, and construct. Currently, the design/build approach in architectural education serves various ends.

Early on, Carpenter (1987) introduced the idea of building as a learning tool in construction studios to grasp the connection between thinking and making, which remains valid in this era. Carpenter's view further suggests an 'experiential learning' approach, which engages all senses, especially touch and hapticity, to register knowledge. Experiential learning emphasizes "learning from experience or learning by doing" (Lewis & Williams, 1994, p. 5).

In the act of building as a learning-by-doing tool, knowledge is not only acquired by the eye and mind but also by the hand and the whole body. The knowledge is thus embodied. It merges not only ontology and representation but also mind and body. Along these lines, international debates on teaching construction in architectural education also underline a paradigmatic shift in construction teaching "from a learning-by-studying and learning-by-being-taught to a learning-by-doing process or rather to a learning-by-playing one" (Voyatzaki, 2002, p. 15).

Based on the literature review, the authors derived from the dynamics between ontology and representation in design/build pedagogy and designed an experiential facilitation approach to enable students to access construction knowledge splitting and merging ontology and representation. The study further contributes to the literature by revealing how construction learning occurs when merging ontology and representation.

4. Research Methodology

The authors have designed this study as action research due to its intention for active curriculum development through the ongoing revision of construction courses. Action research is widely used in education to develop pedagogical practices and revise methods and approaches systematically. It positions researchers as 'reflective practitioners' (Schön, 1983). Ontologically, action research deals with dynamic and human-modified reality situations (Coghlan & Brydon-Miller, 2014). Epistemologically, action researchers see knowledge as something they generate and a living process. Knowledge derives from people's own life, performances, and learning experiences. In action research, information is never static or complete; it is in continuous development as new understandings emerge (Mcniff & Whitehead, 2002). Action research operates as a "spiral of cycles of planning, acting, observing and reflecting" (Carr & Kemmis, 1986, pp. 125–126; Kember, 2000, p. 19). This method, which entails developing a horizon while acting, is similar to the assumptions of hermeneutic philosophy about the circularity and broadening of the horizon. Therefore, the analysis framework of this research is based on the cyclical relations of the hermeneutic circle (Gadamer, 1988).

This research was conducted in 'Construction' taught by Aktuna and 'Construction Project' taught by Karahan. Both courses took place parallelly in Fall 2022 when each course had only one section. The instructors exposed students to 'experiential learning,' which immerses learners in an experience that leads them to reflect on the experience "to develop new skills, new attitudes, or new ways of thinking" (Lewis & Williams, 1994, p. 15). Along the lines of action research, this research led to revisions. It allowed reflection on the outcomes for further actions and revisions. In this study, planning denotes the preparation for new action, i.e., course modification. Acting refers to the conducting of the course each semester. Observation happens during classes and enables data gathering. Reflection occurs through a comparison of course outputs and thematic data analysis, and it prepares for the next planning cycle.

The first action cycle started when Aktuna, an outsider with a different background, joined the department in Spring 2021 and joined the 'Arch 110: Construction' course. At that time, the teaching methods of construction courses had followed lecturing and drafting. In Fall 2021, Aktuna had a pilot study in the course, which entailed introducing teamwork, model-making, and hands-on engagement with materials and methods covered in the course after the inspiring pedagogical work by Huang (2020) to allow student encounters with materials, principles, and systems. Aktuna presented the course outcomes to colleagues at the end of the semester. Consequently, model-making was introduced more systematically to the course in Spring 2022, positively impacting student works, performances, and interests.

In Fall 2022, Aktuna and Karahan revised both construction courses holistically, which entailed the revision of the course content order, theoretical lessons, application methods, and evaluation approach. In these courses, the authors introduced multiple modes of instruction and representation. This introduction sought a balance between lecturing, drafting, model-making, and building toward the repeated splitting and merging of ontology and representation of the building. It further sought to foster potential benefits of individual, group, and collective work and enable a learning process that depends on the instructor, peers, and the self. The authors compared course outcomes for Fall 2022 to previous semesters. The data were collected separately in both courses.

This study employed thematic data analysis to define the essential themes of experience in accessing construction knowledge. Maguire & Delahunt (2017, p. 3353) describe the aim of thematic analysis as "to identify themes, i.e. patterns in the data that are important or interesting, and use these themes to address the research or say something about an issue." Braun & Clarke (2006, p. 87) suggest six phases in conducting thematic analysis: "familiarizing yourself with your data," "generating initial codes," "searching for themes," "reviewing themes," "defining and naming themes," and "producing the report." During thematic analysis, the authors read the data closely to create as many categories as possible and write a label that best describes each category (Norton, 2019). After the authors followed six steps of thematic analysis separately for both data sets from the two courses, the authors created a unified narrative of findings. The themes guide planning and acting as the next steps in course revision.

4.1. Engagement with the 'Construction' Course

The 'Construction' course was revised in Fall 2022. The course content remained the same: reinforced concrete structural frame systems, foundations, slabs and stairs, timber roofs, walls, wall openings, plans and partial sections of the foundation, slab, and roof, architectural floor plans, and entire sections and elevations. However, it was revised to include various application methods more systematically. Besides drafting, the application methods included modeling/ model-making ***(Figure 1)*** and building workshops ***(Figure 2)***. Rather than the individual working methods of the preceding semesters, students worked individually on drafting, in pairs for model-making, and collectively for building activities. The course also depended on industry seminars with applications and demonstrations. The brick manufacturer Kilsan gave a lecture followed by a wall-building application ***(Figure 3).*** The glass manufacturer Roto Frank held a seminar supported with window prototypes.

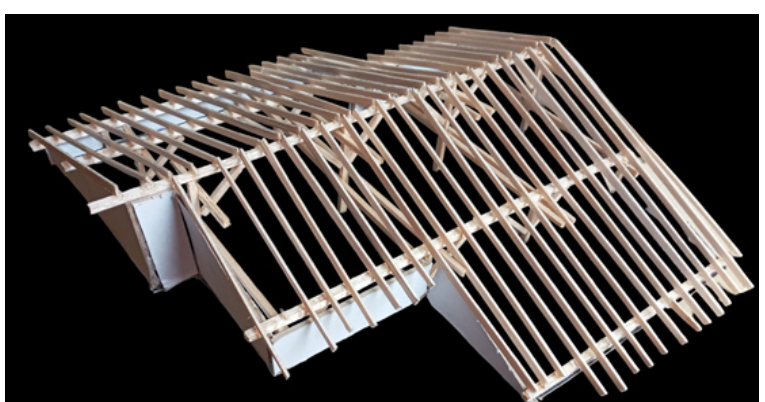

Figure 1. *Model by Defne Akalın & Serra Erdag*
(Photograph by Bahar Aktuna).

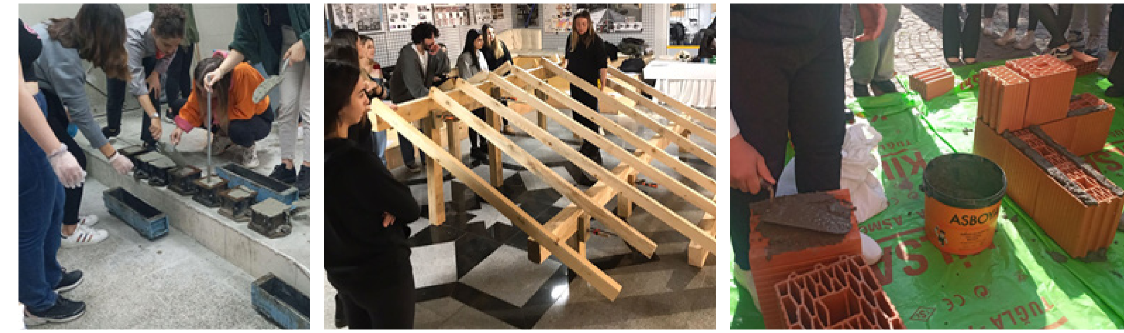

Figure 2. *Building workshops*
(Photographs by Bahar Aktuna & Umut Bektas).

The course included 18 enrolled students who followed the course. Three students were retaking the course—two of them for the third time. In the course, Aktuna observed the learning environment and created one midterm and one end-of-the-term surveys to compare student responses to different engagement methods with knowledge. The midterm survey asked to rate different methods' efficiency in fostering access to construction knowledge. The final survey asked similar questions in more detail to allow more nuanced responses. The surveys asked students to rate each instruction method between 1 (not efficient) and 10 (fully efficient). This survey, not designed for quantitative analysis, helped to establish initial observations and generate interview content for qualitative analysis.

A semi-structured interview took place at the end of the semester after the final exam but before the grades were announced. Aktuna conducted interviews with six volunteering students with a range of passing grades. She held the discussions with each student separately and asked: "What have you learned from this course? Which topics did you learn best? Which methods of this course were liberating or challenging? What knowledge will stay with you the longest? What were some fun moments? What was most challenging about the course?" The interviews were recorded with a tape recorder and transcribed. Both interviews and observations on student work and performances shed light on the success of multiple methods that depend on splitting and merging ontology and representation.

4.2. Engagement with the 'Construction Project' Course

The 'Construction Project' course was conducted with 19 registered and regularly attending students. The course content remained the same: site plans, floor plans, sections, elevations, and stair system detail, timber frame and steel frame structures, slab, stair, roof, and facade cladding systems in line with the principles of preparing a construction application project. The students applied the topics covered in the theoretical courses to their previous construction projects, designed as a reinforced concrete carcass system. They positioned their current project on sloping land, added a basement, designed a part of their project as a timber frame, changed some of the existing reinforced concrete slabs to steel-bearing and timber-bearing slabs, and designed a single-flight timber or steel staircase. Theoretical lectures were supported by digital presentations, videos, and drawing on the board. Technical drawings, three-dimensional modelling, model-making ***(Figure 3)***, and building workshop methods were used in the course applications. The workshops produced a timber slab and roof ***(Figure 4)*** in actual scale and materials. During all studies, the instructor paid attention to the active use of student-instructor dialogue.

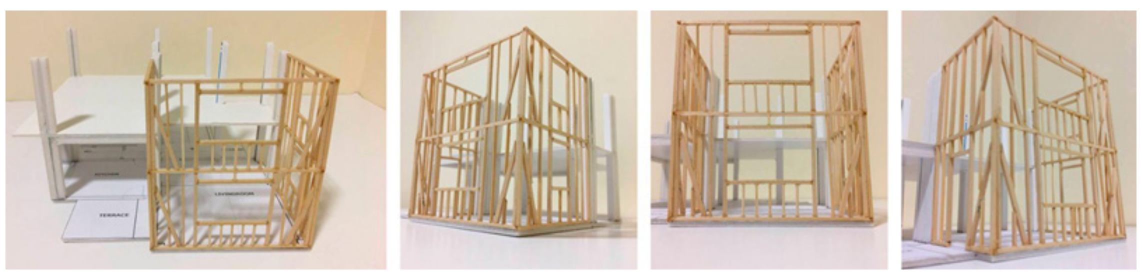

Figure 6. *Model by Pavel Fefelov*
(Photographs by Pavel Fefelov).

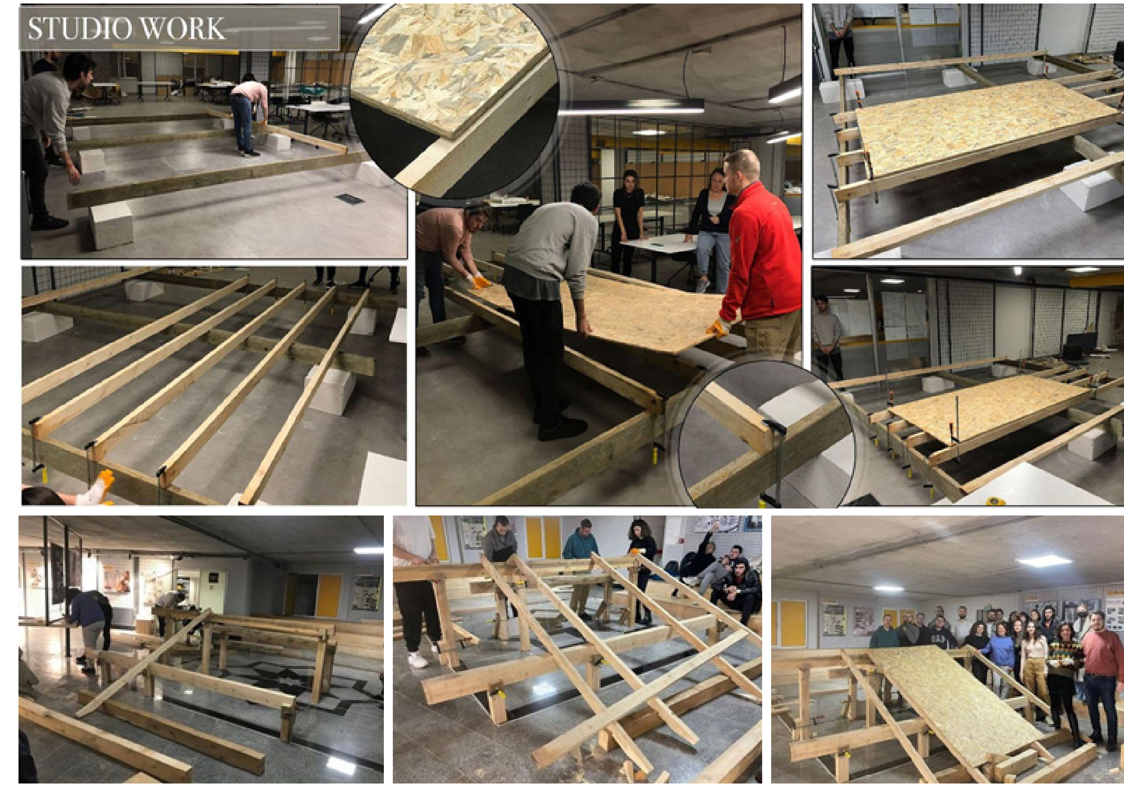

Figure 4. *Building workshops*
(Photographs by Rıdvan Özel & Yonca Alın).

Throughout the 'Construction Project' course, Karahan made observations and created three surveys. Karahan conducted the first survey with the participation of nineteen students after the timber slab building workshop. In the first survey, the students were asked how many times they took this course, and if more than once, the reasons for their failure. Another question asked whether the workshop helped them understand the subject. The last question asked to explain the basic principles of timber slabs with sketches to evaluate the workshop's learning outcomes. Karahan conducted the second survey after the wood frame roof workshop, and six students participated. The survey asked to assess the teaching methods of the course between 1 (not efficient) and 10 (fully efficient) and to explain the basic principles of the timber frame roof with sketches. The instructor further observed the students throughout the semester. The third survey was conducted before the final exam. Karahan surveyed the students' experiences of the instruction methods through semi-structured questions and collected written answers from fifteen students. Questions were asked about the subjects the students had the most difficulty with, the reasons for this, and the evaluation of the contribution of the instruction methods to their learning.

5. Results

In 'Construction,' there was a radical improvement in student work, especially the representation of construction knowledge in technical drawings. The success rate of the course was also higher than in the previous semesters. Thus, the authors interpret that introducing multiple methods increased access to construction knowledge and construction thinking. The midterm survey results (Table 2), which provide supporting data for thematic analysis, highlight student preference for building, teamwork, modeling (as a more accessible realm of representation), individual critiques on drawings, enlarged view of representation, collaboration, and collective discussions. The final survey results (Table 3) highlight student preference for studying existing construction drawings (precedents), individual critiques, building workshops, visiting firm seminars, drawing, model-making or building after theoretical lectures, peer learning, and learning from our everyday environment. The interview content will be presented as a narrative format in the 'Discussion' and show how the students have experienced the access to construction knowledge.

Table 2. First survey, 9 November 2022 (Developed by Bahar Aktuna).

	1	2	3	4	5	6	7	8	9	10	11	12	13	total
..... Lecturing through course slides	10	5	8	8	2	4	10	10	10	-	6	2	6	81
..... Note-taking	9	5	0	8	7	7	9	10	10	-	5	4	3	77
..... Self-study through lecture slides	8	6	10	8	10	3	10	10	10	10	5	3	6	99
..... Weekly readings of course sources	5	0	0	9	2	0	10	10	10	10	7	3	7	73
..... Model-making	10	8	7	10	9	10	10	10	10	10	8	5	8	115
..... Individual drafting on your desk as in class exercise	10	5	4	8	8	9	10	10	10	5	6	5	6	96
..... Collective drafting on the whiteboard	10	7	10	8	10	8	9	10	10	8	7	10	4	111
..... Individual drafting on your desk as homework	10	7	0	8	7	8	10	10	10	10	7	10	7	104
..... Building workshops	10	10	10	10	4	10	10	10	10	8	10	10	8	120
..... Individual critiques	10	9	2	10	6	10	10	10	10	10	10	10	10	117
..... Collective pin-ups and discussions	10	8	10	10	8	10	9	10	10	10	8	10	-	113
..... Group discussions on projections of student works	10	10	10	10	7	9	10	10	10	8	10	10	9	123
..... Teamwork	10	10	10	8	8	8	9	10	10	10	9	10	10	122
..... Individual work	10	7	0	10	9	8	9	10	-	10	7	5	8	93
..... In-person critiques	10	7	0	9	7	10	10	10	-	10	10	10	10	103
..... Online critiques	10	7	0	10	10	5	10	10	-	1	4	0	8	75

Table 3. Second Survey, 7 December 2022 (Developed by Bahar Aktuna).

	1	2	3	4	5	6	7	8	9	10	11	12	total
THEORETICAL LECTURING-BASED METHODS													
Weekly lecturing through lecture slides	10	8	9	10	3	10	10	8	10	9	6	7	100
Taking notes in the class	8	8	10	10	4	9	10	6	8	2	5	2	82
Self-study through lecture slides	8	1	10	10	1	8	10	7	10	6	5	8	84
Weekly readings of course sources	9	-	10	10	0	10	10	9	5	6	5	8	82
Studying a drawing made by the instructor together	10	10	10	10	8	10	10	10	10	8	10	10	116
Lecturing before drawing, modeling or building	10	10	10	10	5	10	10	8	10	9	10	10	112
Lecturing during drawing, modeling or building	10	1	10	10	6	10	10	7	10	7	10	7	98
Lecturing after drawing, modeling or building	10	1	10	10	4	6	10	5	5	3	10	5	79
DRAFTING-BASED METHODS													
Individual drafting as in-class exercise	8	10	7	10	8	9	10	10	8	8	10	10	108
Individual drafting as homework	10	3	9	10	6	9	10	10	8	5	10	7	97
Collective drafting on the whiteboard	10	10	10	10	7	10	10	10	8	8	10	8	111
Individual table critiques	10	8	10	10	9	10	10	10	10	9	10	10	116
Individual online critiques	10	1	10	10	3	10	10	10	10	0	10	8	92
Collective pin-ups and discussions	10	3	9	10	5	9	10	8	10	6	5	6	91
Group discussions on screen projections of student works	10	1	9	10	4	9	10	8	10	6	6	6	89
Drafting after modeling	10	1	10	10	7	6	10	7	8	6	10	8	93
Drafting after building	10	1	10	10	7	9	10	7	5	6	10	10	95
Drafting after viewing your peers' drawings	10	10	9	10	7	10	10	9	8	7	10	9	109
CRAFTING-BASED METHODS													
Model-making as homework	9	3	10	10	7	10	10	9	5	5	10	8	96
Model-making in class	8	10	7	10	6	8	10	8	2	7	5	8	89
Model-making before drawing	9	1	9	10	7	5	8	7	5	6	10	5	82
Model-making during drawing	8	3	7	10	5	8	10	8	10	3	5	10	87
Model-making after drawing	9	10	10	10	5	9	10	9	5	8	5	8	98
BUILDING-BASED METHODS													
Hands-on building workshops	10	10	10	10	10	10	10	10	8	8	10	9	115
Visiting firm seminars	10	10	10	10	10	10	10	10	8	4	10	8	110
Studying our built environment	10	10	10	10	10	10	10	8	8	6	10	7	109
Building after drawing	10	10	10	10	8	10	10	10	10	0	10	9	107

In ‘Construction Project,’ most of the 19-student class consisted of students who had already taken this course once or twice (three students for the first time, five students for the second time, and eleven students for the third time, according to the first survey). Taking the course several times and failing made the students disinterested. Working with multiple methods increased the students’ motivation and enabled them to follow the course more closely. The second mid-term survey, conducted with six students, shows that model-making, building workshops and individual critiques of their work helped students to access construction knowledge (Table 4). The thematic analysis of the survey data is presented in the ‘Discussion’ section.

Table 4. Second survey, 12 December 2022 (Developed by Esra Karahan).

	1	2	3	4	5	6	total
Lecturing through course slides	7	10	8	5	10	6	46
Video screening	8	10	9	6	9	6	48
Model making	10	8	10	10	10	9	57
Individual drafting on your desk as in class exercise	10	7	8	7	10	6	48
Individual drafting on your desk as homework	7	4	5	6	9	6	37
Individual three-dimensional works	10	6	8	8	7	8	47
Building workshops	10	10	10	10	8	10	58
Individual critiques	8	8	10	7	10	10	53

6. Discussion

The content of the interviews and surveys majorly communicates what students comprehended, what they learned well, and what was helpful and fun. It also contains what was challenging, but a positive learning experience outweighs the challenges. Presented below, the retrieved interrelated themes reveal how the students grasped different aspects of construction thinking that fold into the logic of construction.

“It was Like Cooking!”: Revelation of Immediacy and Ordinariness

In construction courses, the students are called to imagine the representation of things. The representation makes things far away, hindering their immediate and everyday being. The construction activities happen somewhere far away from the students, and these activities are inaccessible in their minds. However, when building hands-on, they engage with tools, materials, sizes, measurements, and details, overcoming the impenetrable distance to the construction world. Along these lines, the students repeatedly referred to the liberating effect of casting concrete and framing a roof when those become everyday activities like cooking: “Pouring concrete liberated me, and I will never forget that day. [...] We all got our cement there; we mixed it all together. Oh, let’s put some water. It was like cooking [...]. It didn’t feel far, frankly, dealing with concrete.” Similarly, in applied seminars, the students grasped the immediate connection between an object and its representation:

> *I found the Roto Frank seminar very informative. Seeing the information on the slide they gave us in front of a window and showing it to us with that window cut in half was also beneficial for me. Because I could really see the intermediate elements of the window. And I was very impressed that they gave examples from the windows in our classroom. If necessary, they gave examples from daily life.*

Sometimes, the students engaged with the sections of real-size building elements; they learned to see plans and sections in objects. Thus, orthographic drawings further became demystified. One student noted how she came to understand the representation, on plans, of stairs that run several stories:

> *The stairs were more accessible because we discussed the need to cut the stairs at eye level in one of our lessons. When we went out of the classroom and cut from this level on the school’s stairs, it became easier for me to make sense of the stairs. The stairs seemed more accessible because things were directly in front of my eyes.*

One of the exercises entailed stretching ropes as the axes to find the intersection points to place columns. Although it had been harder to get students to draw axes as an important symbol on the drawings in previous years, students learned from making axes tangible this time. Along these lines, one student noted: “When we showed the axes with the rope, it was very effective.” In the current revision of the course, the axes were laid on the models at the beginning of the semester while designing the structural frames. They were also laid on the floor during the roof-building workshop to mark the places of the studs. Thus, the immediate connection to the symbols through showing their essence to construction is ongoingly practiced.

Opposite to the demystification of representation and access to things, as noted above, several students stated the inaccessibility of foundations as the 'hidden' elements of buildings: "I had trouble with the foundation plan because it's a piece we don't see much. Frankly, I had difficulty not seeing it around me." Another student said, "It was the foundation I had the most difficulty with; grasping the foundation plan had been hard." In response to this struggle with the representation of foundations, the instructors incorporated foundation modelling into the current semester, enabling students to lay out foundation plans simply while making the model without realizing that they were already drawing them.

"Ah, That Gap Between the Purlin and the Wall!": Illumination of the Unnoticed Details

Besides allowing encounters with mystic tools, materials, and elements, building workshops allowed students to look closer at the objects of representation. Building the roof frame allowed them to pay attention to joints and details students never noticed and felt were important to represent. On the other hand, the construction drawings depend on these small joints and details in their constructive logic. Along these lines, one student elaborated on how she had a revelation on the connections of roof components she observed in the 1:1 building workshop.

> *When I placed the purlins, I did not pay any attention to the small details, like I had to leave a gap between the purlin and the wall when I drew them last term. [...] I understood it much more easily when we had the 1/1 application. [...] Actually, I couldn't think much in my mind about how the rafters would be placed or how much I could leave the gaps. I am much more comfortable now. [...] While placing the rafters in my head, I did not fully grasp that the rafters should meet each other like this. I didn't realize that the right and left sides (rafters) had to meet each other when they ended at the ridge. I used to stagger them. But I realized that they had to meet each other.*

"Yes, It is All the Same Thing!": Revelation of the Cross-referential World of Construction Drawings

Although inherent to the logic of construction projects, cross-referentiality is hard for most students to grasp and apply. The switching among multiple media enabled students to comprehend this basic concept of construction thinking. One student describes how that logic was revealed to her when she was transferring the roof from one medium to another after the first failed attempt to model it correctly:

> *In fact, we realized that we could draw the plan, take a section from the plan, and make the model more easily from the section. While I was doing all these at that time, I actually understood drawing the roof plan. Then, adjusting the slope when I cut the section, shifting the ridge, and all these details became much easier.. That's why making models was also very good. Afterward, we corrected the model and received critique. 1:1 practice, making models with my teammate, drawing in class, and getting criticism, all of them were very useful. I can't single out any of them; they were all beneficial.*

Internalizing Knowledge

Construction courses, in addition to giving basic building information, also focus on identifying the problems of the building and the methods of producing solutions in line with the determinations. Students are expected to deliver solutions in line with the issues using the primary education they have received. At this point, knowledge's internalization is significant to find answers to changing structural problems. The internalization of knowledge also describes the ability to access new information by using what is known in the face of differing situations beyond understanding and grasping knowledge. In this respect, internalizing knowledge is essential for construction courses.

Opposite to the demystification of representation and access to things, as noted above, several students stated the inaccessibility of foundations as the 'hidden' elements of buildings: "I had trouble with the foundation plan because it's a piece we don't see much. Frankly, I had difficulty not seeing it around me." Another student said, "It was the foundation I had the most difficulty with; grasping the foundation plan had been hard." In response to this struggle with the representation of foundations, the instructors incorporated foundation modelling into the current semester, enabling students to lay out foundation plans simply while making the model without realizing that they were already drawing them.

After the timber slab and roof workshops, the students were asked about the contribution of the application to their learning. The following answers were received: "Practicing is catchy," "Seeing and touching the material, dealing with it, and coming to a conclusion has been very effective," "Trying methods, trial, error, and retrying made it easier for me to understand," "With these applications, our drawings gain dimension and become more instructive," "I think that making the applications in 3D provides ease of learning and makes the information permanent," and "Doing the roof and slab construction step-by-step was more efficient and memorable than watching it on a slide." The students stated that they found the workshop practices positive regarding memorability, that is, the internalization of knowledge.

In the building workshops, they encountered the actual dimensions and materials of the structural elements they had represented with orthographic drawings, and they understood the potential and problems of the material. These experiences gave students a radical improvement in their understanding and internalization of construction knowledge. They could translate this knowledge into the representational medium of sketches ***(Figure 5).***

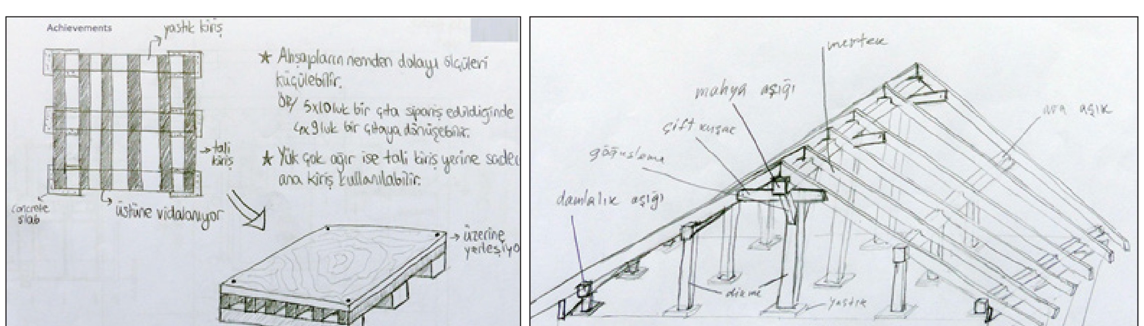

Figure 5. *Student sketches*
(Images by Esra Karahan).

Learning-by-enjoying

Students are passive learners in theoretical lessons, while the instructor is active. In long theoretical lectures, students become alienated from the subject. The students are still passive during critiques. However, the roles change in practices where the student actively participates. The instructor takes a passive position as an observer and supporter when necessary, and the student takes an active position as a producer. There is also some play in the student's work using materials and working in a team. In teamwork, all peers participate in the play. The word 'play' contains a childlike joy in it. When the students were requested to interpret the study after applying the timber slab, they initially and immediately said that: "It was a delightful application," "It was a different experience, and it was enjoyable," "Being fun encouraged learning more," and "I wish we could learn every subject by practicing like this; we both learned and had a lot of fun." Building culture fosters teamwork and active communication. Although being a serious activity with the need for job safety, the building workshops allowed connection, jokes, and fun moments during the long building process.

The findings illuminate the experiential process of students as anecdotal moments of confrontation with the reality of the building. Gaining and regaining a perspective into construction knowledge is challenging but possible through engaging with various scales (including 1:1) and media. Through multiple methods presented here, the students gained the skills to move between ontology and representation by constantly regaining a perspective of the entity under study and processing and narrating the reality surrounding representation through their moods, senses, feelings, and embodiment.

The interpretation of the findings contributes to designing the teaching of construction courses to enable students to access construction knowledge more efficiently. The findings underline the importance of parallel engagement with reality directly and while learning to represent it through other tools, and they indicate the importance of providing an educational landscape to students to engage with construction knowledge hands-on, collaboratively, and diversely. Retrieving essential themes as an ongoing process allows us to reflect on the issues surrounding students' learning process and re-plan the instruction of construction courses accordingly.

7. Conclusions

This action research has confirmed the success of experiential learning and found that applying knowledge through maintaining the diversity of representation results in enhanced learning of construction courses. It has further retrieved experiential anecdotes of learning. This study was limited to two construction courses at Yeditepe University but has wider implications for teaching of construction courses in general.

Since the action in this research started, there has been ongoing progress in grafting construction thinking in the architecture program. The course instructors have accumulated much experience, and the successful works of students have also built up to create the infrastructure and artifacts of new building culture. This study indicates the importance of providing the required environment for the multiple-methods approach, such as material and building laboratories and building workshops in educational institutions to support the realm of construction courses.

Due to the importance of experiential learning in supporting knowledge acquisition, it is vital to include elective courses, such as design/build, in the curriculum, where experiential learning is at the forefront and can support construction courses.

As these experiences and accumulations contribute to the newer generation of construction students, the authors will follow the impact on students' design studio work in future research. Following the reflections of construction courses on design studios and students' professional practices is essential. The inclusion of new techniques and methods will follow as the authors continue to act, observe, reflect, and plan toward founding a more robust building culture.

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Conflict of Interests

The authors declare no conflict of interest.

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