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Multilayered and Interacting Course Design Approach in Architecture Education: A Case of Building and Construction Technology Courses and Studios

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Abstract: Building and construction technology education is a crucial component of architecture education, providing knowledge on tools and methods for designing and realizing building designs. While it provides knowledge as an input to other disciplines, it is also supported by the knowledge the other courses offer. On the other hand, these multilayered and interacting relations within the fields of architecture education may not be well-reflected in education curriculums, or implementation problems may occur. However, designing the architecture education curriculum based on these interacting relationships directly affects the education quality and educational outcomes.

Within this respect, the AGU Department of Architecture provides a flexible curriculum design, which aims to provide experience in research and design during undergraduate architecture education and raise responsible team leaders or members. Therefore, building and construction technology courses of the curriculum are designed following the paths of the department's and the university's educational principles to engage all architecture disciplines with a multilayered and interacting approach. This paper explains the course design approach developed for and experienced with building and construction technology courses by aiming to contribute to the architectural design education literature from the technology education perspective. It sets forth the instructional design models and teaching methods used for designing the building and construction technology courses and also explains the course interactions within the curriculum.

Keywords: Architecture education, Technology education, Building technology, Construction technology, Flipped classroom, Active learning.

1. Introduction

Technology-based courses and studios are one of the backbones of architecture education. Therefore, architecture education should aim to foster an understanding and proficiency in designing by merging information about technical design processes and building service systems into a unified entity during the design phase. Accordingly, technology courses should focus on life safety, building physics, environmental systems, building envelope systems, building service systems, building materials and applications, and the integration of building systems issues (MIAK, 2023). In addition, these subjects should tackle the effects of the physical environment on human health and safety, ethical considerations in professional practice, and legal requirements. It should also encompass established and emerging building technologies, construction techniques, and the evaluation methods architects use to determine their suitability for meeting the design, financial, and performance goals of projects (NAAB, 2020). Moreover, the design-thinking processes should be engaged when approaching building materials, construction techniques, and technology subjects by empowering the students to expand their knowledge and utilize design skills (Koch, Schwennsen, Dutton, & Smith, 2002).

Although the stakeholders of architecture education emphasize the role of technology education, it may not be reflected in education curriculums, or implementation problems may occur. However, the architectural curriculum should be developed concerning the connection between design and technology courses extending beyond theoretical principles. It should also be integrated into all program components to emphasize its essential significance in the field (Smith, 1987).

Within this context, Huang, Lv, and Zou (2013) point out new demands from architectural designers that reveal the inadequacy of traditional building technology education and the need for expanding the scope of building technology education to better nurture students with distinctive qualities. According to the authors, since it is a complex and comprehensive endeavor, it requires streamlining the course structure, managing relationships with related disciplines, and balancing theory with practice. Therefore, adjustments in the structure of building technology courses, interdisciplinary teaching of construction technology, and the incorporation of cross-disciplinary education design are required while updating the curriculum to align with societal advancements. Moreover, according to Smith (1987), integrating technology discussions into the architectural curriculum offers several benefits, including a more comprehensive understanding of theoretical principles and a better grasp of their relevance to effective architectural design.

The author designates the importance of curriculum developments to enhance the effectiveness of architectural education, particularly in strengthening the relationship between design and technical courses. Within this perspective, Enright (2012) states that design and technology are not separate entities in course design but rather are integral pieces in the development of architectural inquiry. According to Enright (2012), technology courses should be designed to bridge the gap between design and technology pedagogy and developed using collaborative tools for students. At this point, using learning activities covering experiential methods come to the forefront. Brainard, Correa, and Brainard (2019) claim that while conventional building science courses typically rely on lecture-style teaching, there is potential for enhancing student engagement and understanding of technical subjects through experiential teaching methods. Within this context, they indicate the importance of integrating hands-on building science investigations into technical architecture courses to maximize the impact on student engagement and learning through cohesive and comprehensive approaches. In addition, Reno (1992) designates that the inclusion of building technology in architectural design education should cover an approach based on hands-on experience that can effectively merge and apply the integration of formal and compositional elements with technical and constructional aspects. Kostopoulos (2022) strengthen this argument, indicating that integrating building technology knowledge into architectural design education through real-life practical applications enhances students' understanding of building processes on a deeper level.

In this regard, the architectural education of AGU Department of Architecture claims to represent an innovative and flexible approach with its curriculum design. The AGU Department of Architecture curriculum includes compulsory and elective department courses under five main topics: Architectural Design Studio, Architectural Design and Criticism, Building and Construction Technology, Architectural History and Cultural

Heritage, and Professional Practice. Alongside the common courses, AGU's signature courses, named Global Courses, focus on sustainable development goals. The main aim of the curriculum design is to provide interdisciplinary and transdisciplinary approaches while providing experience in research and design during undergraduate education, focusing on a local and global scale to enrich the cultural and social environment. Moreover, it aims to raise responsible team leaders or members having theoretical and practical knowledge, skills, and qualifications (AGU Department of Architecture, n.d.).

Within this respect, Building and Construction Technology (BCT) courses and studios of the curriculum are designed with a multilayered and interacting perspective, providing the relationship between not only BCT courses and studios but also courses and studios from other disciplines. While designing the BCT courses and studios, the education principles of the university and the department are followed for defining instructional design models and teaching methods. Therefore, active learning based flipped classroom model is used by integrating appropriate learning activities specific to each course. Furthermore, while defining the learning outcomes, providing accumulated knowledge is aimed within the BCT courses and studios. On the other hand, the knowledge gathered from other architecture disciplines is engaged in BCT courses and studios, and the BCT knowledge also contributes to these courses of the curriculum. Within this framework, this paper explains this course design approach for contributing to the architectural design education literature from the building and construction technology discipline perspective.

2. Elements of Course Design

While designing a course, it is crucial to prioritize the development of the course structure in alignment with the overall objectives and mission of the educational institution. Once this is established, the appropriate instructional design models should be employed. Subsequently, the teaching methods should be carefully chosen to align with the desired performance of the course design. Finally, the course design should incorporate learning activities compatible with the selected teaching methods.

The "Backward Design" model is mainly used with the revised "Bloom's Taxonomy of Education Objectives" to design a course aligned with the current discussions and applications in higher education. As a teaching method, the flipped classroom model is another current paradigm that provides a student-centered approach using peer learning-based active learning methods through collaborative and cooperative learning strategies for the learning processes.

2.1 Instructional design models

In a traditional course design approach, content is created or adapted, assignments and tests are planned, grading processes are determined, and instructor-focused objectives are defined (DePaul University, 2023). In contrast, the "Backward Design" model proposes defining the desired results of a course first and then focusing on the content, methods, and activities to reach those results (Wiggins & McTighe, 2005). The model consists of three main stages for a course design: identifying desired results, determining acceptable evidence, and planning learning experiences and instruction (Wiggins & McTighe, 2005, 2011).

Within this approach, first, the knowledge, skills, and abilities that the students should have at the end of a course are defined as part of desired results, which are the "goals" of the course, by analyzing existing content standards and examining the curriculum expectations. In the second stage, evidence that can be used for documenting and assessing students' learning is determined. This strategy encourages instructors to think about the assessment procedures before designing the learning activities and how they will know if students have attained the desired knowledge. Finally, the activities and instruction methods that should be included to support students' learning process are planned based on the identified results and appropriate evidence of understanding. While doing so, an instructor should focus on the knowledge and skills that students need to perform well and achieve desired results, including the appropriate activities that provide the required knowledge and skills to students. The teaching methods, materials, and resources are also defined for meeting performance goals (DePaul University, 2023; Wiggins & McTighe, 2005).

While using the “Backward Design” model for designing a course, learning goals, objectives, and outcomes should be clearly defined. “Learning goals” are typically broad statements written from an instructor's perspective, which show the general content and direction of a learning experience by outlining the instructor’s objectives. On the other hand, “learning objectives” are the declarations of the material an instructor aims to cover or teach in a learning experience, which is usually more precise than learning goals and not always measurably or visibly observable. While defining the learning objectives, the emphasis is on the instructor rather than the students, and therefore it supports the instructor when developing more precise learning objectives (DePaul University, 2023). “Learning outcomes” outline what a student can do as a result of completing a learning experience successfully in observable and quantifiable terms. Learning outcomes support instructors when defining the expectations from the students, designing their teaching methods, resources, and evaluations, making necessary revisions on the curriculum to enhance student learning, and assessing how the outcomes of a single course align with the outcomes of an entire program. On the other hand, they assist students by explaining the benefits of an educational experience, providing to follow their development, and making them aware of the evaluation criteria beforehand. Therefore, learning outcomes should be “student-centered,” “measurable,” “concise,” “meaningful,” “achievable,” and “outcome-based” (DePaul University, 2023).

The “Bloom’s Taxonomy of Education Objectives” is a tool used for defining educational objectives. The main aim of building a taxonomy of educational objectives is communicating in academic research and curriculum development (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). Although an education curriculum is established based on teachers’ and students’ behavior and instructional methods, Bloom’s Taxonomy classifies how students are expected to behave, think, or feel after engaging in a particular instructional unit (Bloom et al., 1956). In the revised taxonomy, the educational objectives are defined based on two dimensions: knowledge and cognitive process (Anderson et al., 2001). The knowledge dimension focuses on “factual,” “conceptual,” “procedural,” and “metacognitive” knowledge (Anderson et al., 2001). While “factual knowledge” focuses on terminology and specific details and elements, “conceptual knowledge” primarily includes classifications, principles, and theories. Moreover, “procedural knowledge” concerns subject-specific skills, techniques, methods, and criteria for using appropriate procedures. Finally, “metacognitive knowledge” deals with strategic knowledge, knowledge of cognitive tasks, and self-knowledge (Anderson et al., 2001; Patricia, 2010). On the other hand, cognitive processes focus on “remembering” to recall facts and basic concepts; “understanding” to explain ideas or concepts; “applying” to use information in new situations; “analyzing” to draw connections among ideas, “evaluating” to justify a stand or decision, and “creating” to produce new or original work (Anderson et al., 2001; Patricia, 2010). When the educational objective of a specific learning process, such as a course, is determined, the appropriate cognitive process is linked with a proper knowledge dimension (Anderson et al., 2001).

2.2 Teaching methods

Teaching is designed based on the expectations from a learning process, which has various components to consider when designing a course. According to Mayer (2008), learning is the transformation of knowledge that results from the learner's experience. It depends on the learner’s cognitive processing, which includes choosing the pertinent incoming material, organizing it into a coherent mental representation, and connecting it with knowledge from long-term memory (Mayer, 2008). Schunk (2012) defines learning as an ongoing modification of behavior or the capacity to act appropriately in a particular way resulting from any experience. According to Schunk (2012), learning includes change, continues over time, and happens through experiences. Therefore, learning should be planned as a process comprising the changes in knowledge, beliefs, behaviors, or attitudes (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). While designing a learning process, students' prior knowledge, motivation, developmental stage, opportunities for practice and feedback, and developing their ability to learn independently should be considered (Ambrose et al., 2010).

Education, in which learning is provided, must evolve as it adapts to new demands, new ways of learning, new ways of managing information and knowledge, and the integration of technology (Alonso de Castro & García-Peñalvo, 2022 in García-Peñalvo, Sein-Echaluce, & Fidalgo-Blanco, 2022). Therefore, there has been a shift from traditional teacher-centered learning to student-centered learning approaches due to the new paradigm that offers active participation of students in their learning (Ambrose et al., 2010; TEAL Center, 2010). In the teacher-centered learning approach, the teacher acts as the recognized role of the classroom and provides information to students who passively obtain the offered knowledge. On the other hand, in student-centered learning, teachers and students play equally active roles in the learning process, where the teacher is still an authority figure in the classroom by taking more of a facilitator or coaching role, while students take a more active and collaborative role in the learning (edX, n.d.; Lathan, 2023). Within this context, the flipped classroom model with active learning methods, supported by peer learning, becomes the core of student-centered learning.

“Flipped classroom” or “flipped learning” is an innovative student-centered active learning approach supported by technology-based learning environments (Campillo-Ferrer & Miralles-Martínez, 2021; Elrayies, 2017; Michigan State University, n.d.; The Derek Bok Center for Teaching and Learning, n.d.). It combines online and on-campus learning by flipping the traditional model of using class time for lectures and assigning homework, also called “reverse teaching” (Nouri, 2016; Reidsema et al., 2017; Roehling & Bredow, 2021). Instead of attending lectures in class and completing homework afterward, students watch digital or online lecture videos and read course materials as preparation before class to learn the material, and then use their in-class time to participate in teacher-led hands-on learning activities like group discussions, presentations, problem-solving activities, and projects that are aligned with the online material (Nouri, 2016; Reidsema et al., 2017; Roehling & Bredow, 2021). Therefore, flipped learning provides a flexible environment for learning by changing the learning culture. It allows students to take ownership of their learning and progress at their own pace and enhances their motivation, engagement, learning outcomes, and learning effectiveness by fostering a collaborative learning environment (Michigan State University, n.d.; The Derek Bok Center for Teaching and Learning, n.d.).

“Active learning” refers to any teaching method in which students work independently or in small groups to increase student engagement in lectures or class discussions by enhancing the learning environment (Bean & Melzer, 2021; Berry, 2008; Keyser, 2000; Mabrouk, 2007). Within this context, the active learning methods aim to increase students' interest in learning and enthusiasm for learning. They also provide strategies for strong thinking and rational reasoning for maximizing their intellectual development (Bean & Melzer, 2021; Bonwell & Eison, 1991). Active learning methods share some common characteristics as encouraging independent and critical thinking in students; holding students accountable for their learning; engaging students in a variety of activities to enable them to take a more active and less passive role; and considering the role of educators in providing appropriate learning activities in which students can explore and develop their knowledge base and mindset (Kane, 2004). The mostly used active learning approaches include collaborative and cooperative learning methods in which problem-based, case study, and experiential learning approaches are widely used (Bean & Melzer, 2021; Berry, 2008; García-Peñalvo et al., 2022; Mabrouk, 2007; Prince, 2004; Vince & Reynolds, 2007).

“Collaborative learning” approach focuses on social and intellectual engagement and shared responsibility by promoting collaboration, which holds significant potential for enhancing student learning (Leigh Smith & MacGregor, 1992). The fundamental principle of collaborative learning is rooted in the idea of achieving consensus by working together cooperatively as a group, which values and emphasizes the capabilities and contributions of each group member (Hogarth, 2010). In most collaborative learning activities, students work in groups of two or more, searching for understanding, solutions, or meanings or collectively creating a project by actively engaging in the process (Leigh Smith & MacGregor, 1992). Collaborative learning experiences promote positive student interdependence, facilitate their integration into the learning process, increase their motivation, and provide a greater awareness of their academic career path (La Rocca, Margottini, & Capobianco, 2014).

“Cooperative learning” is a form of active learning in which students work in small groups with defined roles and tasks for each student to learn a specific content (Felder & Brent, 2007; Keyser, 2000; Mabrouk, 2007). A cooperative learning environment has certain conditions that include individual accountability for the entire content of the task to achieve a shared objective (Felder & Brent, 2007). However, personal responsibility is still emphasized to reach the group's goals. Even within a group setting, each student's performance is individually evaluated, and they are held responsible for making a meaningful contribution to the group's success (Leigh Smith & MacGregor, 1992). Therefore, cooperative learning activities are designed to ensure every learner contributes to the collaborative task by promoting interaction where students engage in constructive dialogue, communicate, and assist each other with formal or informal approaches (Leigh Smith & MacGregor, 1992; Mabrouk, 2007). Since the cooperative learning approach is based on the idea that working together is better than competing in enhancing academic achievement and attitudes, it promotes effective teamwork and interpersonal skills together with achieving positive learning outcomes (Prince, 2004). Establishing positive interdependence between students; personal responsibility; meaningful and personal face-to-face communication between students; social interaction; applying appropriate collaborative skills; and group evaluation and reflection are some vital elements of cooperative learning (Felder & Brent, 2007; Mabrouk, 2007).

It has been recognized for a while that peer interactions, or interactions between students, provide an opportunity for students to practice and reinforce their skills, which can lead to learning and skill consolidation. Therefore, cooperative and collaborative active learning approaches are also supported by “peer learning”, which takes advantage of student variations and transforms them into valuable learning opportunities. There are two types of peer learning: mutual and directional peer learning. “Mutual peer learning” refers to situations where students collaborate in small groups to accomplish academic tasks, fostering the development of shared knowledge and skills by having mutual responsibilities and contributing to the interaction equally. In contrast, “directional peer learning” involves one student taking the responsibility of assisting another student or a small group of students with academic tasks (Topping, Buchs, Duran, & van Kesser, 2017). Within this context, both collaborative and cooperative learning approaches involve the construction of knowledge in a multidirectional manner, where information is shared among all members and relationships dynamically flow (Iborra, García, Margalef, & Pérez, 2010). Specifically, in collaborative learning, responsibilities are expected to be distributed equally between peers with similar statuses, resulting in a high level of equality (Topping et al., 2017). On the other hand, cooperative learning is characterized by group members mutually engaging in coordinating tasks with the aim of constructing knowledge. While each member is directly responsible for their learning, they are also indirectly responsible for the learning of other group members (Iborra et al., 2010).

The widely used active learning approaches included in collaborative and cooperative learning methods are defined as problem-based, case study, and experiential learning approaches (Bean & Melzer, 2021; Berry, 2008; García-Peñalvo et al., 2022; Mabrouk, 2007; Prince, 2004; Vince & Reynolds, 2007).

“Problem-based learning” approach enables students to explore real-world problems that are unconstrained and often ill-defined through group activities (Mabrouk, 2007). As a result, problem-based learning can effectively achieve crucial learning outcomes, such as fostering positive student attitudes, promoting a deeper approach to learning, and facilitating longer retention of knowledge compared to traditional teaching methods. In addition, problem-based learning methods engage students in analyzing and solving complex problems and provide developing lifelong learning and problem-solving skills (Leigh Smith & MacGregor, 1992; Prince, 2004).

“Case studies” are often used as part of collaborative and problem-based learning approaches by providing context-based environments for active learning (Mabrouk, 2007). A case study is a narrative of a real-life situation that presents a problem, an unresolved tension, a designed short story, or an existing case to summarize essential facts about an event that explains principles studied in class for students to analyze and resolve (Leigh Smith & MacGregor, 1992; Mabrouk, 2007). Case studies focus on past events but can also help look to the future. It also differs from a problem-based study since it usually does not involve data collection (Mabrouk, 2007). Although cases do not need to involve collaborative learning or small group discussion, case method-based teaching often involves small groups of students working together to tackle issues during class or study sessions (Leigh Smith & MacGregor, 1992).

“Experiential learning” is a form of active learning through practical experience, allowing students to connect academic theories and knowledge learned in the classroom to real-life situations by engaging in hands-on experiences (Boston University Center for Teaching & Learning, n.d.; Kent State University, n.d.). Experiential learning aims to promote active engagement among students, facilitating the creation of real-life examples that can be used to analyze and reflect on the subject's emotional, relational, and political aspects (Vince & Reynolds, 2007). Moreover, experiential learning proposes different approaches to education, the interplay between learning, work, and other life activities, and even the generation of knowledge (Kolb, 2015). According to Dewey (1997), the educative value of experience depends on the extent to which it builds on a foundation of essential knowledge and how much this knowledge alters or adjusts the learner's perspective, approach, and abilities. Therefore, experiential learning involves presenting concepts to students in a comprehensive manner by fostering both individual learning and collective critical reflection (Vince & Reynolds, 2007). Within this context, examples of experiential learning activities include conducting experiments, completing internships, participating in field exercises, studying abroad, conducting research, and performing in a studio setting (Boston University Center for Teaching & Learning, n.d.).

3. Building and Construction Technology Courses and Studios

Technology has mainly two primary elements: physical components and knowledge (Kumar, Kumar, & Persaud, 1999). While the physical component comprises tools (materials, equipment, machinery, labor, etc.) and methods (process, action, technique, etc.), the knowledge component encompasses the accumulation of expertise in areas such as production and skilled workforce providing scientific knowledge and technical abilities (Edis, 2006; Gray & Hughes, 2001; Kumar et al., 1999).

In the architectural profession, two types of technology occur: building and construction technology. Building technology is the practical application of the technical processes, methods, and knowledge necessary for assembling materials into a building (O'Sullivan, 2014). The building technology practice fundamentally focuses on bringing together the materials and components for a building design to provide shelter to its occupants by considering the necessary comfort conditions according to the building's function, users, and environmental constraints (Charlett, 2007). On the other hand, construction technology includes innovative tools, machinery, and software used during on-site construction practices to increase efficiency (CII, n.d.). Furthermore, it comprises the techniques employed in construction, the stakeholders involved in decision-making and execution throughout the process, such as employers, architects, engineers, contractors, subcontractors, and laborers, and the essential knowledge needed during the process (Chudley & Greeno, 1999). Since all of the technology components, such as any information, knowledge, data, materials, equipment, human resources, techniques, activities, and processes, provide a variety of options and relations to be considered during the decision-making phases of the building processes, the critical position of the technology courses in the architectural education should be indicating and interiorizing these aspects by using different teaching methods.

When considered from this point of view, the BCT course module of the undergraduate architectural education curriculum of AGU Department of Architecture comprises building material, building element system design, environmental control system design, structural design, and professional practice and ethics courses and studios. While "Structure 1" and "Structure 2" courses deal with the engineering aspect of structural system design, the "Professional Practice & Ethics" course focuses on the ethical concerns and various practices involved in the field of architecture throughout different stages of building production. On the other hand, "Materials & Behaviors," "Elements & Components 1", "Elements & Components 2", and "Building Technologies" courses and studios cover the building material, building element system design, and environmental control system design topics, respectively. Therefore, the course content, objectives, and learning outcomes of these courses, which handle building and construction technology components directly, are designed based on a multilayered and interacting perspective not only within the BCT course model but also focusing on the other compulsory courses and studios of the curriculum.

Consequently, when designing the BCT courses and studios, the educational principles defined by Abdullah Gul University (AGU CELT, 2020) are followed, and the Backward Design model is used together with Bloom's Taxonomy of Education Objectives. After designing the overall structure of the courses, teaching methods are engaged by selecting appropriate learning activities to meet the course designs' overall performance. For this purpose, the teaching methods of the courses are structured based on the flipped classroom model through a student-centered approach, in which peer learning-based active learning methods are used. Furthermore, collaborative and cooperative active learning strategies are used by integrating the problem-based, case study-based, and experiential learning approaches (Figure 1).

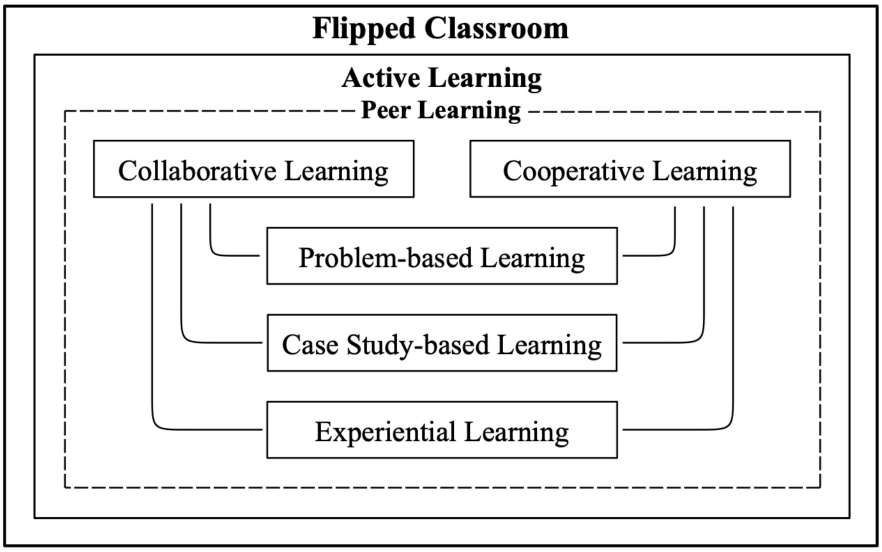

Figure 1: *Course design approach for the building and construction technology courses*

3.1 Materials & Behaviors

The "Materials & Behaviors" course is the first compulsory BCT course focusing on the "material" component of the technology concept in the second semester. It is primarily structured on the theme "Introduction to Materialization" to introduce the building materials through traditional, conventional, and innovative perspectives focusing on their developing and changing properties and usage possibilities. First, building material, component, and element concepts are defined and classified. Then, the basic properties and general characteristics of the building materials are explained by focusing on the environmental factors and user and performance requirements. Furthermore, the building materials are discussed in detail based on the building material selection criteria, such as perception, requirements, and properties, examining the relationship between building material selection and architectural design concept and relating the materials' usage areas with the building element systems. Therefore, the learning outcomes (LO) of the course are described as identifying the difference between building materials, components, and elements (LO1: understand), interpreting the basic properties, inherent characteristics, and performances of the building materials (LO2: apply), examining the building materials based on their usage in the buildings (LO3: analyze), selecting appropriate building materials via detailed research and review processes (LO4: evaluate), and developing proposals for the given design problems using the material knowledge (LO5: create).

The knowledge is provided through online lecture videos, and in-class discussions, feedback sessions, and seminars from material companies, while analysis, research, and design activities, either in-class or out-of-class activities, are used for utilizing the knowledge (Table 1). At the beginning of each class, either before in-class activities or discussions of the out-of-class activities, further examples are provided related to the subject of the week, and students' questions about the online lecture videos are answered as part of the discussions. The material suppliers are also invited to give seminars about their products to integrate the knowledge from professional life into the learning process.

Table 1: *Materials & Behaviors course design*

Learning Activities	Teaching Methods			Learning Outcomes
Lectures**	Flipped Learning	Online Lecture Videos		LO1, LO2, LO3, LO4
Discussions*	Active Learning	Questions-and-Answers Sessions		
Feedback*		Feedback Sessions		
Seminars*		Lectures		
Material Hunting: Literature Analyses**		Collaborative	Case study-based	LO1, LO2, LO3
Materials & Architects Research**				LO2, LO3
Façade Design*			Problem-based	LO2, LO3, LO4, LO5
Material Safari: Built Environment Analyses **			Experiential	LO1, LO2, LO3
The Sense of The Material Research* - **		Cooperative		LO2, LO3

* In-class Activity; **Out-of-class Activity

Whereas "Material Hunting" and "Material Safari" are analysis activities, "Materials & Architects" and "Sense of The Material" are research activities. For the "Material Hunting" activity, students analyze a case building from the literature, focusing on a specific material's usage in detail (Figure 2). On the other hand, students find constructed material examples from the surrounding built environment to analyze and discuss their usage based on possible selection criteria, such as perception, requirements, and properties for the "Material Safari" activity (Figure 2). The "Materials & Architects" research activity focuses on analyzing assigned architects' material usage characteristics in their designs (Figure 2). The "Material Hunting," "Material Safari," and "Materials & Architects" activities are performed as part of out-of-class activities. The outcomes of the out-of-class activities are then discussed, and feedback is provided during in-class activities. The "Sense of The Material" is

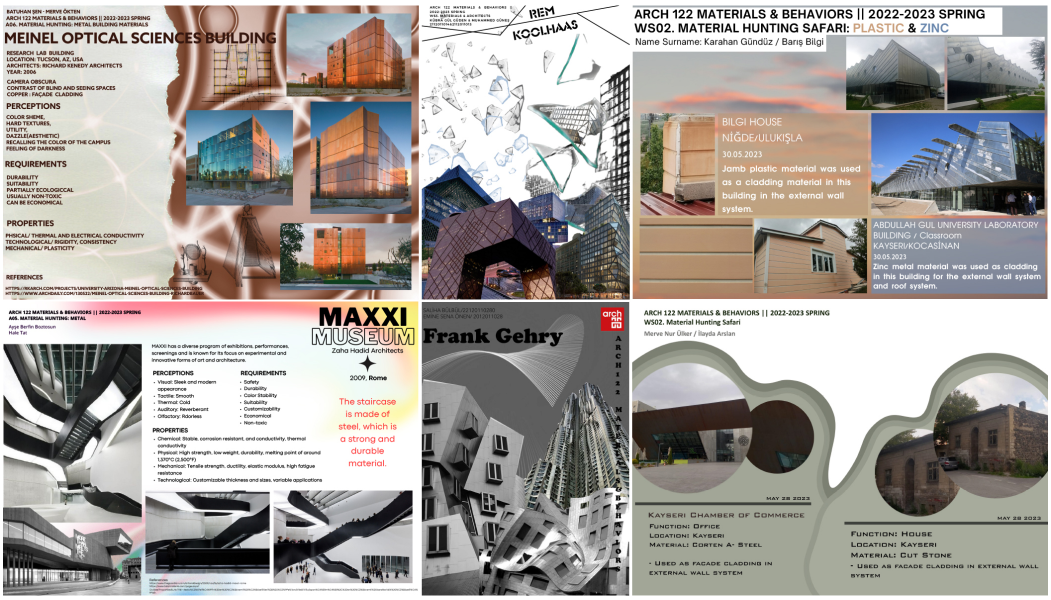

Figure 2: *Examples of the "Material Hunting," "Materials & Architects," and "Material Safari" activities (from left to right)*

Figure 3: *Examples from the exhibitions of the "Façade Design" (above) and "Sense of The Material" (below) activities*

conducted by visiting material suppliers and construction sites to find a material sample and interview the professionals, in which students gather the necessary knowledge as an out-of-class activity and then prepare the outcome and get the feedback as an in-class activity (Figure 3). The "Façade Design" is a studio work conducted as part of in-class activities developed for linking the gathered knowledge to the design process (Figure 3). As part of this activity, the students design facades for the assigned housing projects using the collage technique based on the given design problem and design inputs using the material knowledge they obtained throughout the semester. While the student groups work on the design activity, they get feedback, and, in the end, the outcomes are discussed. While students work in groups collaboratively for "Material Hunting," "Material Safari," "Materials & Architects," and "Façade Design" activities, they work cooperatively for the "Sense of The Material" activity by having an assigned building material specifically for each student.

Table 2: *Elements & Components 1 course design*

Learning Activities	Teaching Methods			Learning Outcomes
Lectures**	Flipped Learning	Online Lecture Videos		LO1, LO2, LO3, LO4, LO5
Discussions*	Active Learning	Questions-and-Answers Sessions		
Feedback*		Feedback Sessions		
Mock-up Applications*		Collaborative	Experiential	LO1, LO3, LO5
Model-making*		Collaborative/Cooperative		
Design Exercises*		Cooperative		LO2, LO3, LO4, LO5
Performance Analyses*/**		Collaborative	Case study-based	LO1, LO2, LO3, LO4
Construction Process Analyses*/**				LO3

* In-class Activity; **Out-of-class Activity

3.2 Elements & Components 1

The "Elements & Components 1" course follows the "Materials & Behaviors" course in the third semester by dealing with the transition from material to component and building element. It is designed on the theme "Systems & Construction," focusing on BCT knowledge through "methods" and "tools" components of the technology concept. The overall intention of the course is to equip the students for a successful building element system design process by providing awareness of its relationship with the architectural design concept and the variety of building materials and detailing options. First, the basic concepts related to building, building systems, performance-based design principles, and construction technologies are introduced. The building element systems are then discussed in detail by focusing on basics, classifications, performance-based design principles, and construction technologies, emphasizing the characteristics of each building element system. Hence, the learning outcomes are described as recognizing the building systems and sub-systems and their integration and relation (LO1: understand), implementing the performance-based design principles to building element system designs (LO2: apply), examining the role of construction technology components in the building element system design process and the realization of the design (LO3: analyze), critiquing the building element system designs based on the user requirements and environmental factors (LO4: evaluate), and developing detailed drawings and models of building element systems for illustrating the use of materials, and components (LO5: create).

The knowledge is provided through online lecture videos and in-class discussions, and feedback sessions, whereas physical model-making, design exercise, performance and construction process analysis activities, and mock-up applications with guest companies are used for utilizing the knowledge (Table 2). Each class starts, either before in-class activities or discussions of the out-of-class activities, by providing further examples related to the subject of the week, and students' questions about the online lecture videos are answered as part of the discussions.

Figure 4: *Examples from the final submission of the "Model-making" activities*

While the physical model-making, design exercises, and mock-up applications are conducted as part of in-class activities, the performance and construction process analyses can be either in-class or out-of-class activities. The primary purposes of the "Model-making" and "Design Exercises" are to understand the building element systems and construction technologies in a three-dimensional way by making physical models first and then to practice using performance-based design principles and detailed design drawing production through design exercises. As part of these activities, student groups first make three-dimensional models of the building sub-systems, either collaboratively to produce a final product or cooperatively having personal tasks to produce an outcome (Figure 4). After the three-dimensional model-making activities, the design exercises cover hand drawings or sketches to present the design solutions or make analyses for building element systems, in which student groups work cooperatively, having a specific task for each student (Figure 5). In these exercises, students follow performance-based design principles based on the given conditions for user requirements and environmental factors. Student groups get feedback during in-class activities, and the outcomes are discussed at the end of class time.

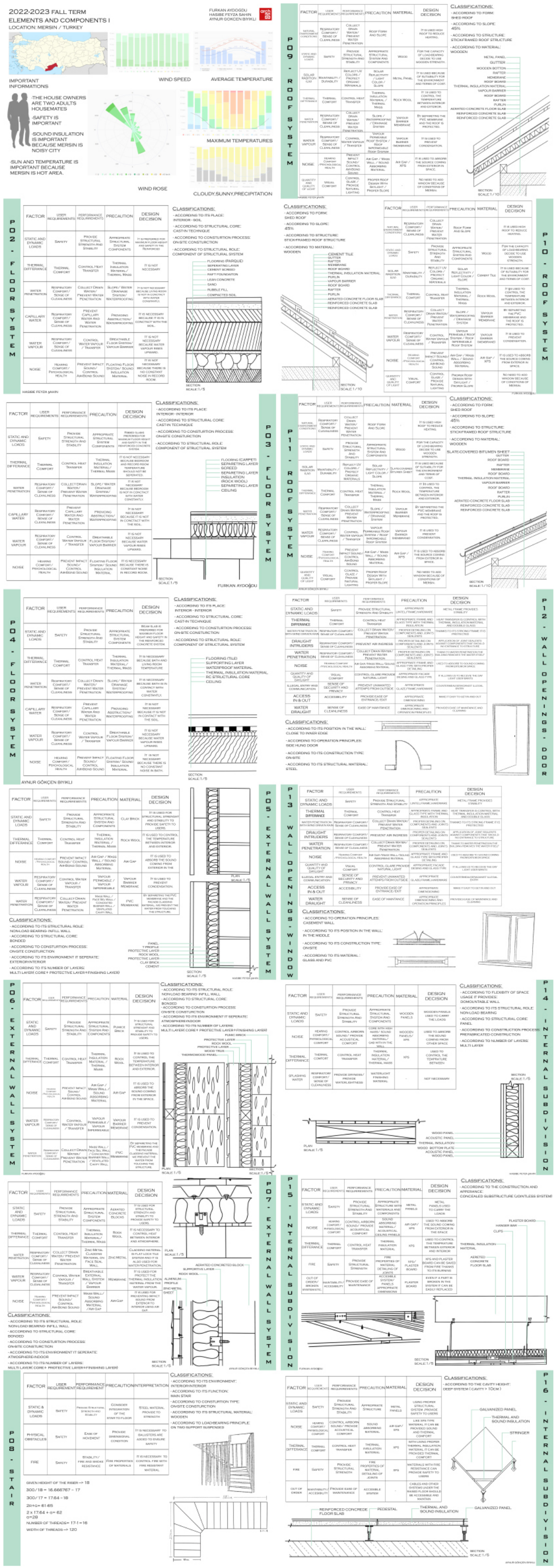

***Figure 5:** An example from the final submission of the "Design Exercises" activities*

"Performance Analyses" are performed using the given case building, either from the literature or the built environment, focusing on the building element system in the subject (Figure 6). On the other hand, "Construction Process Analyses" are performed by watching assigned construction process videos to predict the construction technologies used during the design realization by examining the construction technology components (Figure 7). Student groups work collaboratively for the performance and construction process analysis activities, and the outcomes are discussed during class time. Moreover, mock-up applications are conducted by the guest companies in which students experience the construction techniques and construction process collaboratively under the supervision of the company representative as part of in-class activities.

3.3 Elements & Components 2

The "Elements & Components 2" course is structured on the theme "Design & Integration" by following the outcomes of the "Elements & Components 1" course in the fourth semester. Similar to the Elements & Components 1 course, it focuses on BCT knowledge through "methods" and "tools" components of the

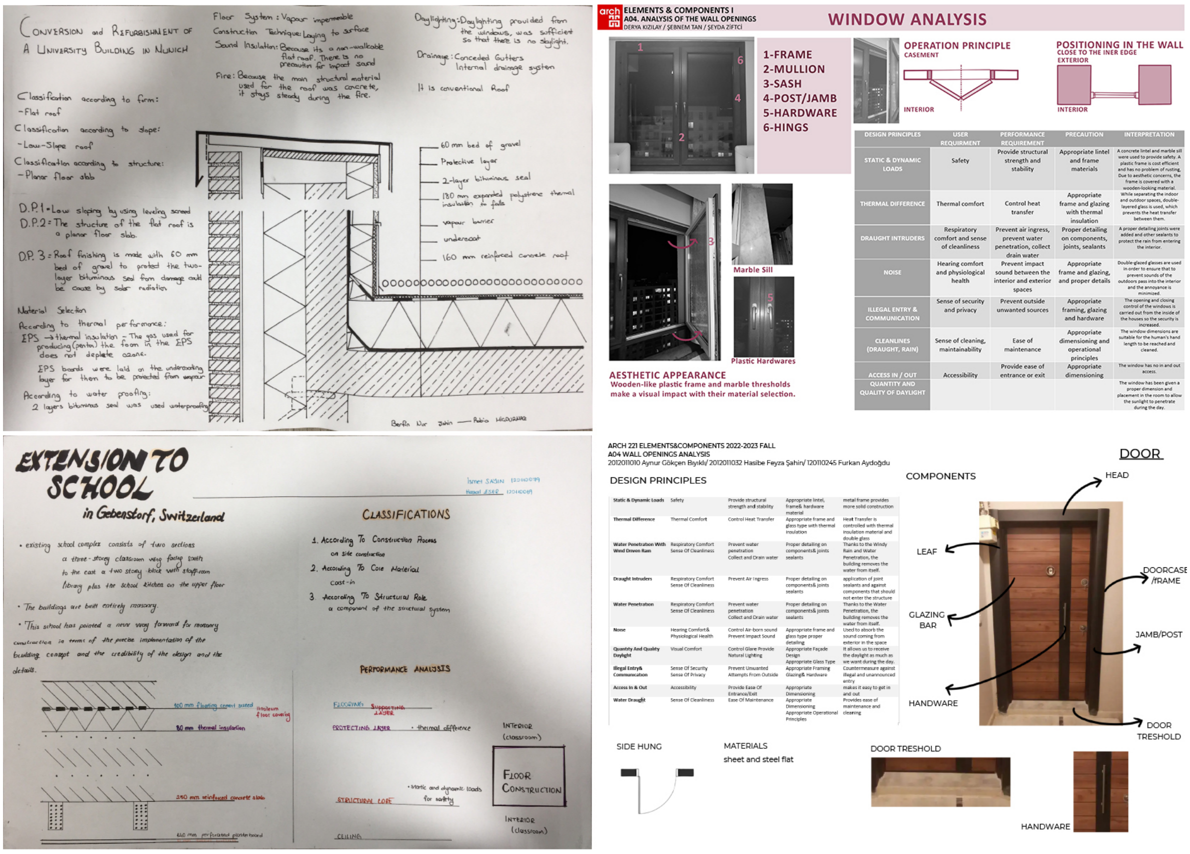

Figure 6: Examples of the "Performance Analysis" activities (left column: case building analyses from the literature; right column: case building analyses from the built environment)

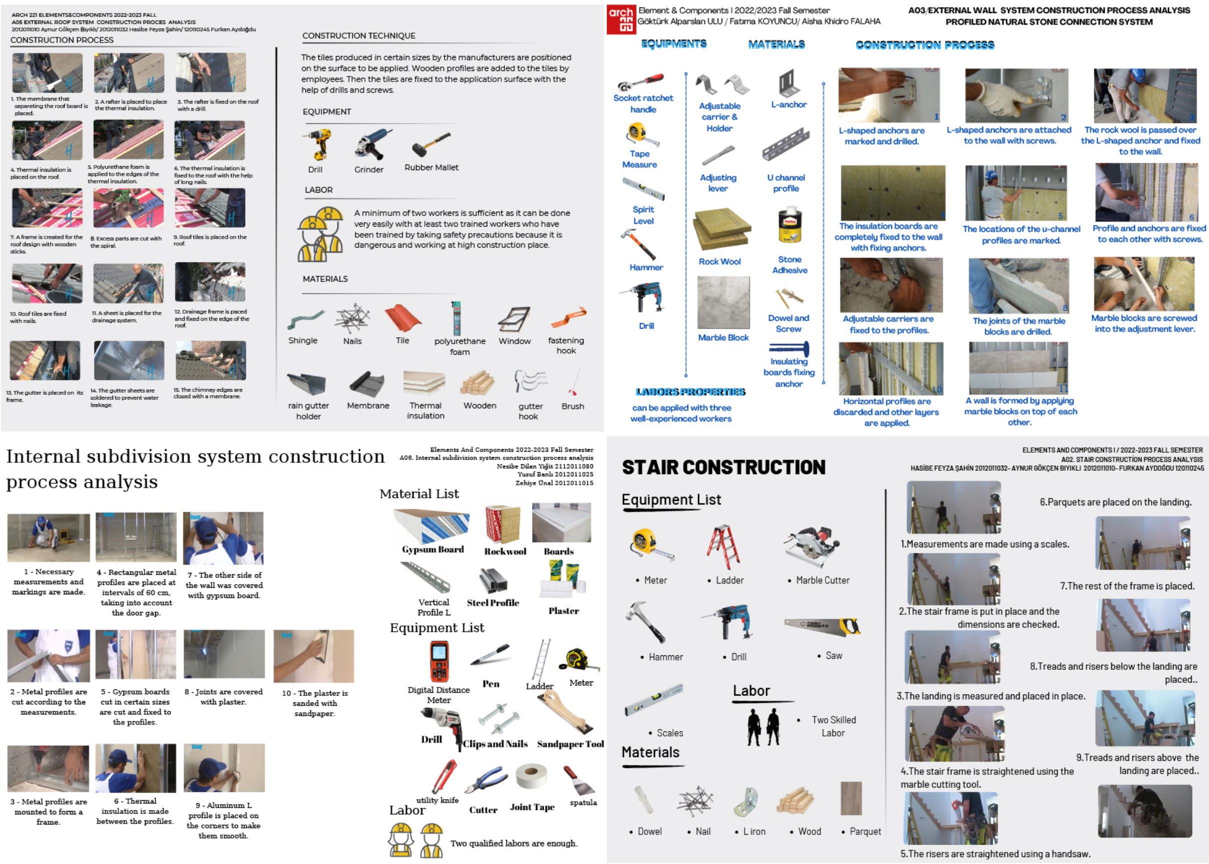

Figure 7: Examples of the "Construction Process Analysis" activities

technology concept in a detailed manner. The course mainly intends to equip the students for a successful detailed design process by experiencing a construction project development using the roadmaps given in the "Elements & Components 1" course. Within this context, the learning outcomes are described as identifying the architectural detail design principles focusing on the integration of the building element systems (LO1: understand), using performance-based design principles for building element system and architectural detail designs (LO2: apply), relating the architectural design concept and detailed design (LO3: analyze), selecting appropriate construction technology components for the detailed design development (LO4: evaluate), and developing detailed drawings and models for identifying the assembly and integration of materials, systems, and components (LO5: create).

While the knowledge is provided through in-class lectures, discussions, and feedback sessions, construction project development and model-making activities are used for utilizing the knowledge as part of out-of-class activities (Table 3).

Table 3: *Elements & Components 2 course design*

Learning Activities	Teaching Methods			Learning Outcomes
Lectures*	Active Learning	Face-to-face Lectures		LO1, LO2, LO3, LO4, LO5
Discussions*		Questions-and-Answers Sessions		
Feedback*		Feedback Sessions		
Construction Project Development**		Cooperative	Experiential	
Model-making**				LO1, LO4, LO5

* In-class Activity; **Out-of-class Activity

For the "Construction Project Development" and "Model-making" activities, students work cooperatively through peer-learning sessions to develop the construction project for their previous architectural design studio project. Throughout the semester, they produce 1:100 scale design development drawings, 1:5 scale details of building element systems, 1:20 scale system details of the building envelope and stair, 1:50 scale construction drawings (Figure 8), and make a 1:20 scale digital or physical model of the building envelope system (Figure 9). For each phase of the construction project development, students get personal and collective feedback, and the discussions also take part during class time.

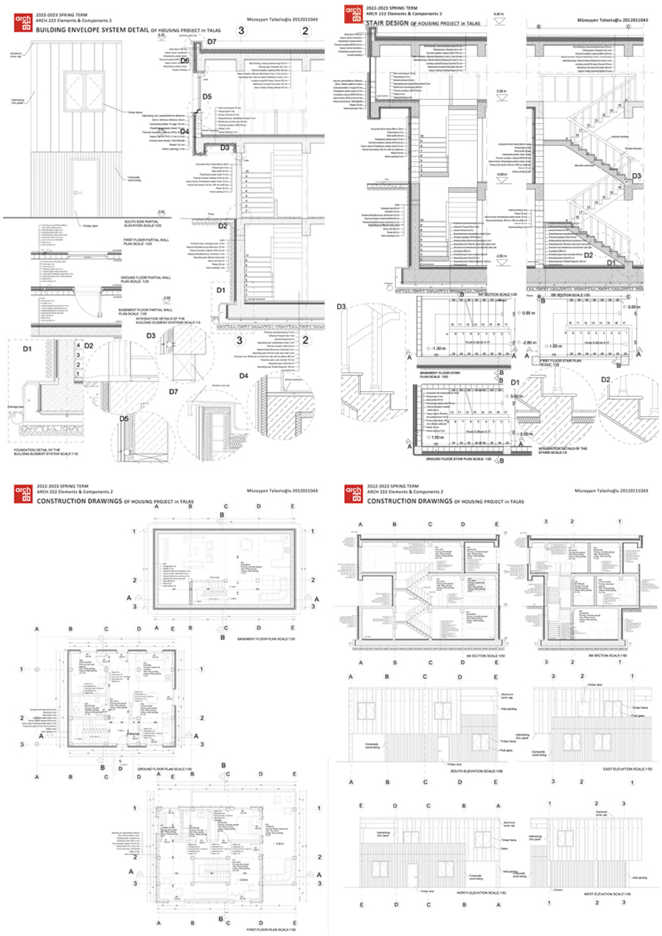

Figure 8: *An example from the final submission of the "Construction Project Development" activities*

Figure 9: *Examples from the final submission of the building envelope system "Model-making" activities*

Table 4: *Building Technologies course design*

Learning Activities	Teaching Methods			Learning Outcomes
Lectures**	Flipped Learning	Online Lecture Videos		LO1, LO2, LO3, LO4, LO5
Discussions*	Active Learning	Questions-and-Answers Sessions		
Feedback*		Feedback Sessions		
Seminars*		Lectures		LO1
Performance Analyses*		Cooperative	Case study-based	LO2
Building Service Systems Design**			Experiential	LO3, LO4, LO5
Building Envelope Design**				
Model-making**				

* In-class Activity; **Out-of-class Activity

3.5 Building Technologies

The "Building Technologies" course is the last BTC course in the seventh semester. It is designed on the themes "Environmental Control" and "Environmentally Responsible Architecture," mainly focusing on building technology knowledge through "methods" and "tools" components of the technology concept. The significant contribution of the course is to equip the students to conduct research and design on the fundamentals of building technologies and their application to buildings. The "Environmental Control" module mainly tackles energy efficiency, fire safety, lighting design, acoustic design, and sanitary installation issues focusing on the current technological advances and innovations in the construction industry. During the "Environmentally Responsible Architecture" module, the current issues considered critical for the built and natural environment are discussed through environmentally responsible architecture and green building envelopes subjects. Therefore, the learning outcomes are described as recognizing the requirements of building service systems by focusing on the importance of interdisciplinary studies and architects' responsibilities (LO1: understand), interpreting the design and construction process decisions based on the national and international regulations and standards (LO2: apply), examining the environmental control requirements of buildings by focusing on the interactions between natural and built environment (LO3: analyze), selecting the appropriate technological solutions and innovations for a specific design problem (LO4: evaluate), and developing detailed drawings and models showing the design decisions on the building service and building element systems (LO5: create).

The knowledge is provided through online lecture videos, and in-class discussions, feedback sessions, and seminars; while performance analyses, building service systems design, and building envelope design, and model-making activities are used for utilizing the knowledge (Table 4). At the beginning of each class, either before in-class activities or discussions of the out-of-class activities, further examples related to the subject of the week are provided, and students' questions about the online lecture videos are answered as part of the discussions. Professionals from other disciplines are also invited to give seminars to reflect the interdisciplinary position of the architecture profession.

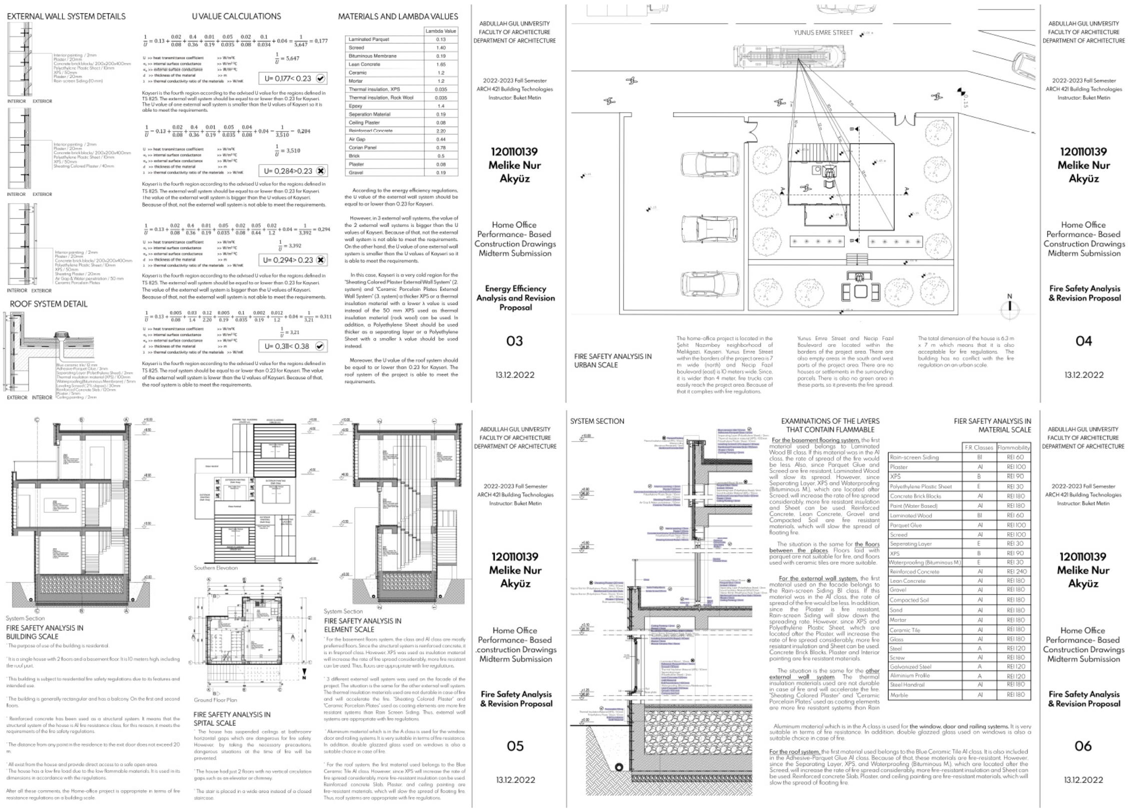

Figure 10: *Examples from the final submission of the "Performance Analysis" activities*

While performance analyses are performed as in-class activities, building service systems design, building envelope design, and model-making activities are conducted as part of out-of-class activities. The students work cooperatively through peer-learning sessions for conducting these activities. As part of the "Environmental Control" module, students conduct "Performance Analyses" on the previously developed construction project to interpret their previous design decisions regarding energy efficiency and fire safety (Figure 10). Since they make these analyses during class time, they get feedback while developing their analyses, and the outcomes are discussed at the end of the activities. On the other hand, they develop detailed drawings for "Building Service Systems," focusing on lighting design, acoustic design, and sanitary installation to enrich and finalize their previous design as part of out-of-class activities and get feedback during class time (Figure 11). In the "Environmentally Responsible Architecture" module, they design a new "Building Envelope" for the previous design using innovative approaches and following environmentally responsible architecture principles. They develop system detail drawings and make three-dimensional digital model of the building envelope to represent their design idea as an out-of-class activity and get feedback during class time (Figure 12).

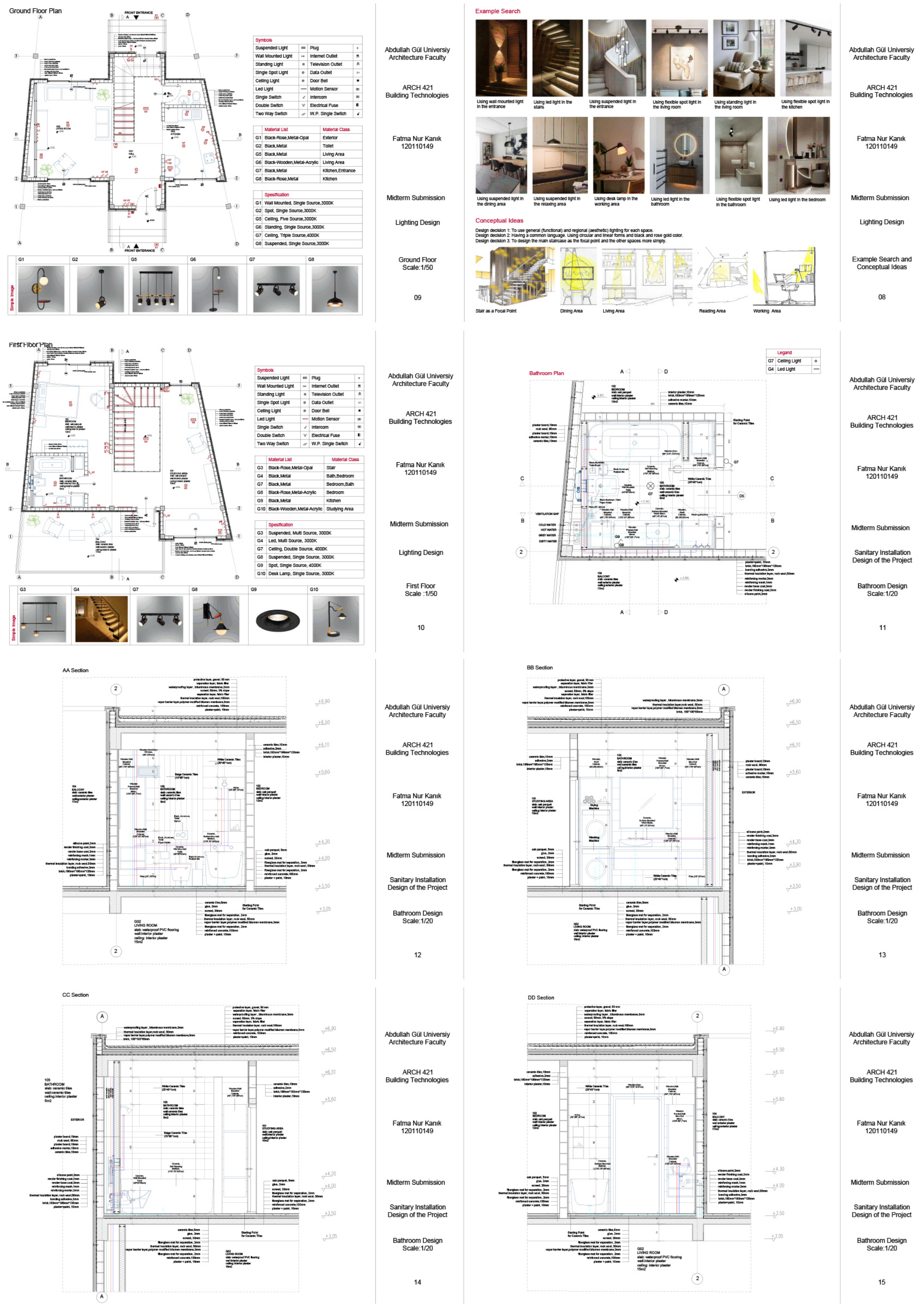

Figure 11: *Examples from the final submission of the "Building Service Systems Design" activities*

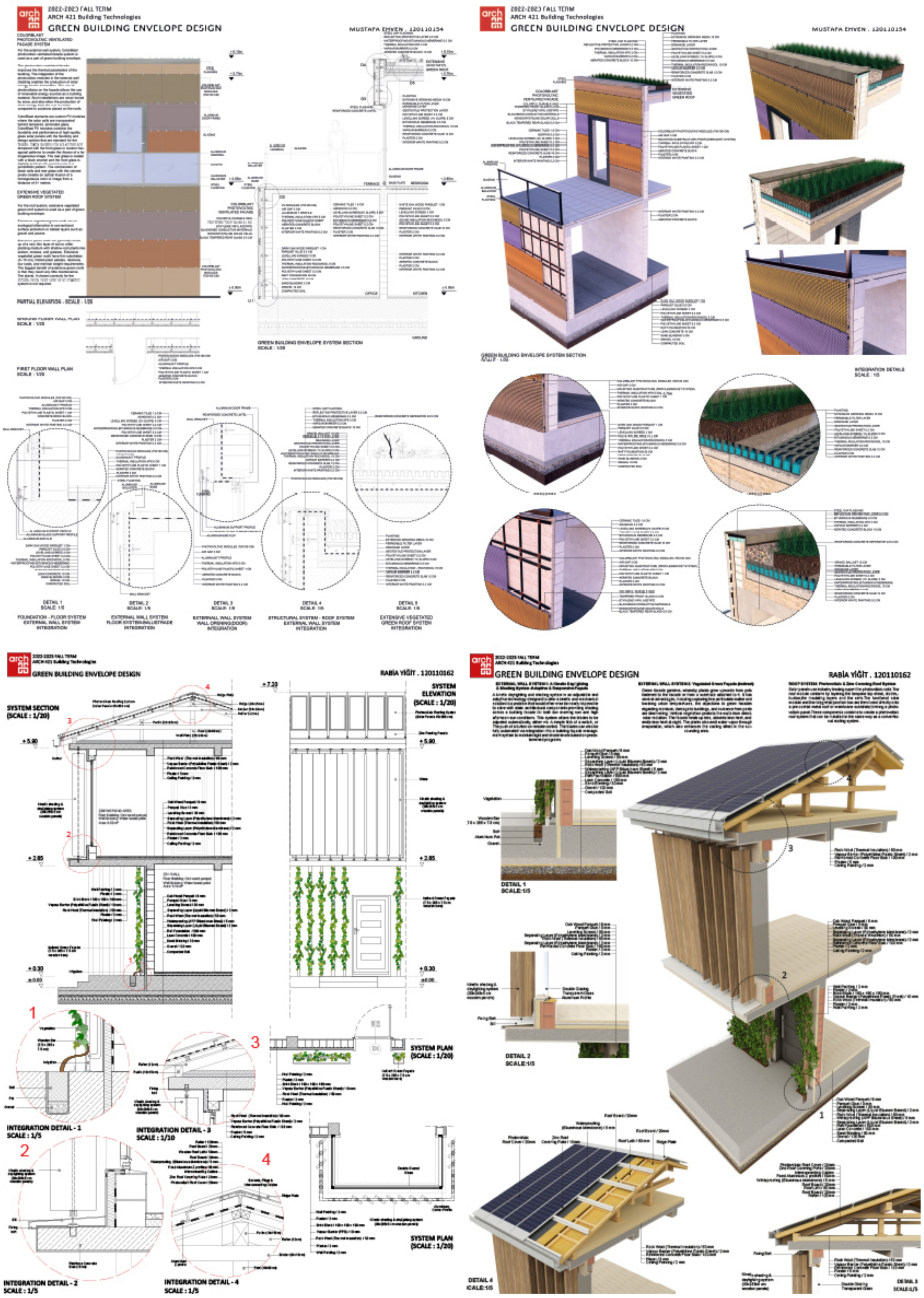

***Figure 12:** Examples from the final submission of the "Building Envelope Design and Model-making" activities*

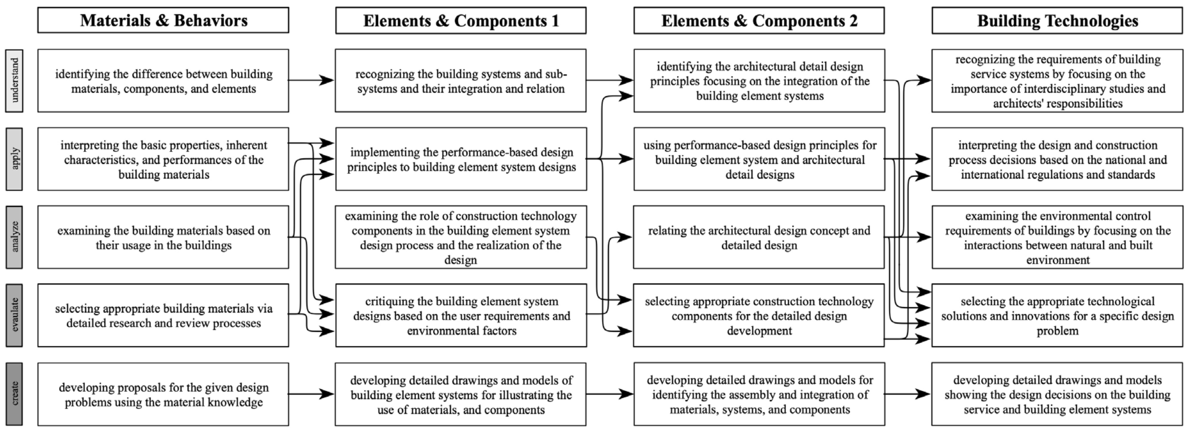

Figure 13: *Multilayered learning outcome relations within the building and construction technology courses and studios*

4. Course Interactions within the Curriculum

The BCT courses and studios are designed to provide knowledge accumulation by relating the learning outcomes within the BCT course module. On the other hand, the accumulated knowledge gathered through BCT courses and studios strongly interacts with the curriculum's compulsory courses and studios from other disciplines as well. The BCT courses provide not only knowledge input for the other courses and studios but the knowledge obtained from other courses is also engaged in the learning activities conducted as part of the BCT courses and studios.

4.1 Multilayered relations within the building and construction technology courses and studios

The knowledge of the BCT field is provided through the cognitive processes of “understand,” “apply,” “analyze,” “evaluate,” and “create, as outlined in Bloom’s Taxonomy of Education Objectives. This knowledge is acquired through specific learning outcomes established for each BCT course and studio. It is not limited to individual courses but encompasses a cumulative accumulation of knowledge throughout the BCT courses and studios, beginning with the "Materials & Behaviors" course and concluding with the "Building Technologies" course (Figure 13).

At the end of the “Materials & Behaviors” course, students identify the difference between building materials, components, and elements, which supports recognizing the building systems and sub-systems and their integration and relation in the “Elements & Components 1” course. Following this, in the “Elements & Components 2” course, identifying the architectural detail design principles focusing on the integration of the building element systems becomes possible based on previous knowledge. Eventually, this accumulated knowledge provides the system thinking perspective to the students. Finally, this knowledge supports selecting the appropriate technological solutions and innovations for a specific design problem in the “Building Technologies” course.

The knowledge gathered for interpreting the basic properties, inherent characteristics, and performances of the building materials; examining the building materials based on their usage in the buildings; and selecting appropriate building materials via detailed research and review processes in the “Materials & Behaviors” course become inputs for the “Elements & Components 1” course. They support implementing the performance-based design principles to building element system designs and critiquing the building element system designs based on the user requirements and environmental factors since material selection is a critical input for these processes.

Afterward, implementing the performance-based design principles to building element system designs enables identifying the architectural detail design principles focusing on the integration of the building element systems, using performance-based design principles for building element system and architectural detail designs, and selecting appropriate construction technology components for the detailed design development in the “Elements & Components 2” course. Finally, using performance-based design principles for building element system and architectural detail designs supports interpreting the design and construction process decisions based on the national and international regulations and standards and selecting the appropriate technological solutions and innovations for a specific design problem in the “Building Technologies” course.

Critiquing the building element system designs based on the user requirements and environmental factors in the “Elements & Components 1” course supports relating the architectural design concept and detailed design in the “Elements & Components 2” course. This relation later provides recognizing of the requirements of building service systems by focusing on the importance of interdisciplinary studies and architects' responsibilities; examining the environmental control requirements of buildings by focusing on the interactions between natural and built environments; and selecting the appropriate technological solutions and innovations for a specific design problem in the “Building Technologies” course.

The knowledge obtained by examining the role of construction technology components in the building element system design and the realization of the design in the “Elements & Components 1” course provides selecting of appropriate construction technology components for the detailed design development in the Elements & Components 2” course. This knowledge then contributes to interpreting the design and construction process decisions based on national and international regulations and standards and selecting the appropriate technological solutions and innovations for a specific design problem in the “Building Technologies” course.

Developing proposals for the given design problems using the material knowledge in the “Materials & Behaviors” course provides the initial representation knowledge for the BCT field. Later, it supports developing detailed drawings and models of building element systems for illustrating the use of materials and components in the “Elements & Components 1” course, which enables developing detailed drawings and models for identifying the assembly and integration of materials, systems, and components in the “Elements & Components 2” course. Moreover, this accumulated knowledge is used for developing detailed drawings and models showing the design decisions on the building service and building element systems in the “Building Technologies” course.

4.2 Mutual interactions with other compulsory courses and studios of the curriculum

While BCT courses and studios provide accumulated knowledge for building materials, building element system design, and building service system design subjects, they are also designed to both receive contributions from other compulsory courses and studios within the curriculum and contribute to them by ensuring a holistic and interacting learning experience (Figure 14).

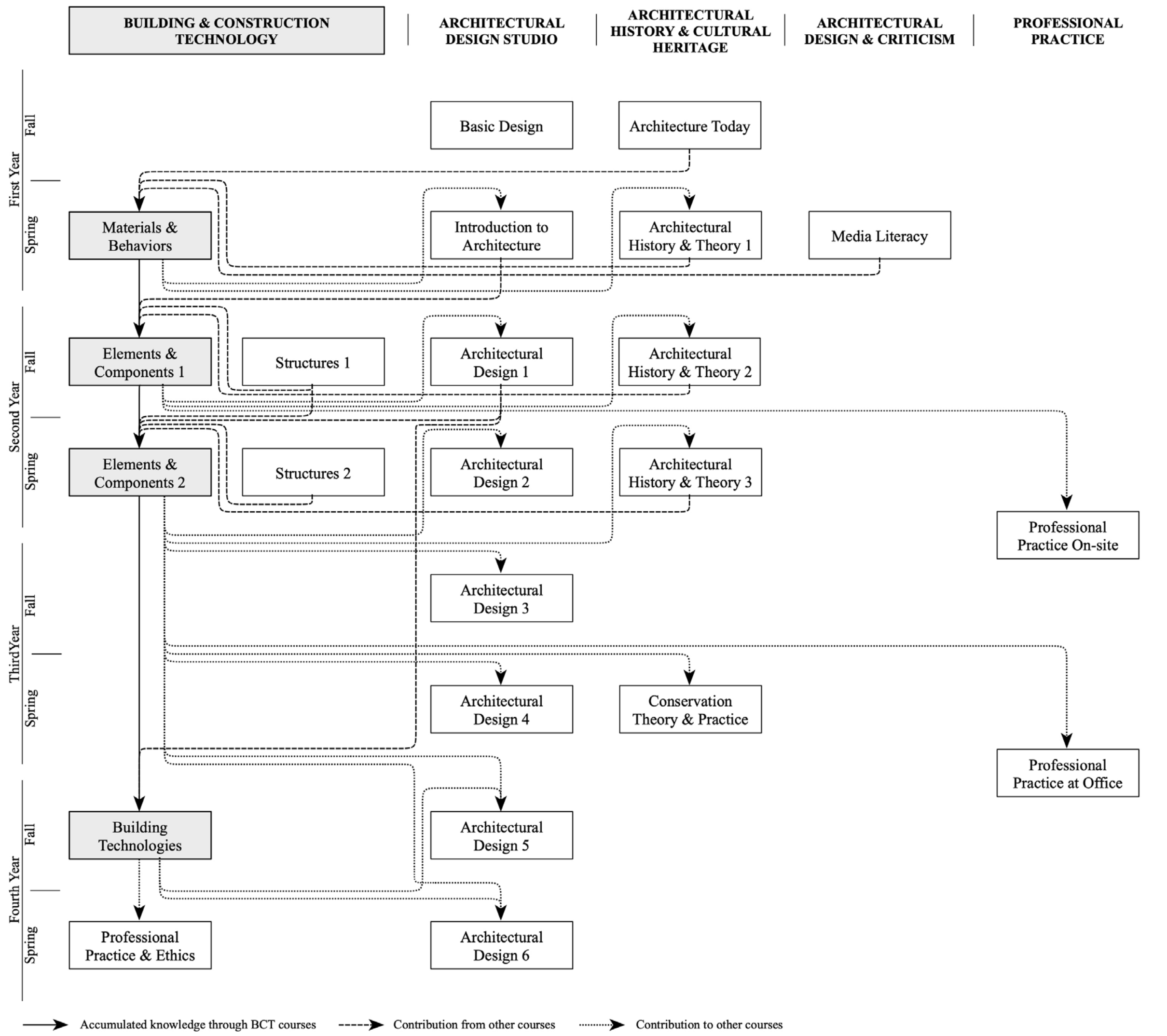

Figure 14: *Mutual interactions with other compulsory courses and studios of the curriculum*

The "Materials & Behaviors" course is contributed by the "Architecture Today" course from the previous semester, and also "Architectural History & Theory 1" and "Media Literacy" courses in the same semester. Since "Architecture Today" deals with the architectural works of both the present time and the twentieth century by developing a perspective on design, architecture, and related fields, the students use this knowledge for "Materials & Architects" and "Façade Design" activities. In addition, "Architectural History & Theory 1", an architectural history course like "Architecture Today," supports the learning activities, providing the technology knowledge of the early civilizations from the settlement of the first cities to the end of the Middle Ages. The knowledge gathered from these courses assists students when examining the usage purposes and selection criteria of building materials in the buildings. Besides, the "Media Literacy" course focuses on various media techniques as tools for communicating ideas. Therefore, students use this representation knowledge to represent the outcomes of the learning activities to prepare posters or use collage techniques to represent their design idea for the given problem. On the other hand, the "Materials & Behaviors" course contributes to the "Introduction to Architecture" design studio and the "Architectural History & Theory 1" course in the same semester. It provides the technology concept and building material knowledge for these courses.

The "Elements & Components 1" course is contributed by the "Introduction to Architecture" design studio from the previous semester, and the "Structures 1" and "Architectural History & Theory 2" courses in the same semester. The "Introduction to Architecture" design studio contributes to the model-making and design exercises by delivering representation knowledge on technical drawing principles and physical model-making techniques. On the other hand, the "Structures 1" course provides knowledge on structural system design, which is used as part of the model-making and design exercises and for performance analysis activities. It helps students to recognize the building systems and sub-systems and their integration and relation. "Architectural History & Theory 2" also provides accumulated knowledge for the technology concept of the architecture of medieval times until the end of the eighteenth century, which supports examining the role of construction technology and critiquing the building element system designs. On the other side, the "Elements & Components 1" course contributes to the "Architectural Design 1" studio and "Architectural History & Theory 2" course in the same semester. It provides the system thinking perspective together with a detailed building element system knowledge that students use as part of the design process in the "Architectural Design 1" studio. Moreover, they use this knowledge for the active learning activities of the "Architectural History & Theory 2" course when discussing different building techniques and technologies in the fifteenth to the eighteenth centuries.

The "Elements & Components 2" course is contributed by "Architectural Design 1" studio, and the "Structures 1" course from the previous semester, and also "Structures 2" and "Architectural History & Theory 3" courses in the same semester. The "Architectural Design 1" studio provides critical input for the "Elements & Components 2" course with the "Housing Project" students develop as part of the studio, which is used for the construction project development process. Moreover, similar to the "Elements & Components 1" course, "Structures" courses contribute to the detailed design development process by providing knowledge on structural system design for designing structural system and building element system integrations. Besides, "Architectural History & Theory 3" provides the technology knowledge on nineteenth and twentieth centuries architecture that contributes to the perspective used for relating the architectural design concept and architectural detail design. On the other hand, the "Elements & Components 2" course contributes to the "Architectural Design 2" studio and the "Architectural History & Theory 3" course in the same semester and also the "Conservation Theory & Practice" studio two semesters later. It provides the building element system and detailed design development knowledge together with the ability to relate the architectural design concept and detailed design and develop detailed drawings and models on different scales. The accumulated knowledge of "Materials & Behaviors," "Elements & Components 1," and "Elements & Components 2" courses and studios contribute to the following "Architectural Design Studios," in which students represent their material selection and detailed design decisions for their studio projects. However, their contribution to the "Architectural Design 3" studio in the following semester is significant, in which alternative building materials and construction methods are discussed and engaged to the studio project outcome.

The "Building Technologies" course is contributed by "Architectural Design 1" studio from the second year since the construction project of the "Housing Project" developed during the "Elements & Components 2" course is used for the performance analyses and developing detailed drawings of the building service systems and building envelope design. Also, it contributes to the "Professional Practice & Ethics" course in the following semester, explicitly providing the ability to recognize the importance of interdisciplinary studies and architects' responsibilities in the architecture profession, and national and international regulations and standards literacy. Furthermore, not only the knowledge gathered with the “Building Technologies” course but also the accumulated knowledge obtained through BCT courses contribute to the “Architectural Design Studios” of the same and following semesters, of which the capstone project is also part.

The BCT courses also contribute to “Professional Practice” activities conducted in the summer. “Professional Practice On-site” is supported by the accumulated knowledge gathered with the “Materials & Behaviors” and the “Elements & Components 1” courses for utilizing the building material, building element system design, and construction technology selection knowledge through practice, and takes place after the second year. On the other hand, “Professional Practice in Office” is contributed by the accumulated knowledge gathered at the end of the “Elements & Components 2” course due to the building element system and architectural detail design, and construction project development knowledge, and performed at the end of the third year.

5. Discussion and Conclusion

The architectural education curriculum requires a holistic approach by engaging all architecture disciplines with a multilayered and interacting approach aligning with the current demands and expectations of the architecture profession. For this purpose, the BCT courses of AGU Department of Architecture are designed with this perspective, following the department’s and university’s educational principles and also selecting appropriate instructional design models and teaching methods. During this process, the course designs have been analyzed and revised according to the students' feedback and self-assessment outcomes at the end of each term. Ultimately, BCT courses are designed using flipped classroom model, in which active learning methods become core and increase the engagement of the students and the instructors. Within this course design model, students obtain knowledge using online lecture videos outside of class, and class times are used for active learning activities, face-to-face discussions, feedback sessions, seminars, and mock-up applications with guest companies. This approach increases the benefits of student-instructor encounters by providing quality time for discussing the outcomes of the learning activities and expanding the discussions on the content of the lectures further. Furthermore, the designs of the BCT courses and studios provide an opportunity to explain and share the relationships with other disciplines by engaging their outcomes to the activities or how the students should use this knowledge for the other courses from the other architecture disciplines.

At the end of their education, AGU Department of Architecture students obtain accumulated knowledge for the BCT discipline, not only due to the course designs of the BCT courses and studios but also relating and using this knowledge in other courses, especially in architectural design studios. Therefore, these multilayered and interacting relations between the BCT courses and studios, and with other compulsory courses and studios of the curriculum, enable students to integrate the knowledge they obtain throughout their architectural education into their architectural design attitudes. Moreover, these curriculum characteristics take them a step further from the multidisciplinary approach by enabling them to think with inter- and trans-disciplinary perspectives corresponding to the AGU’s and AGU Department of Architecture’s mission.

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